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An Illustrated Weekly Journal.

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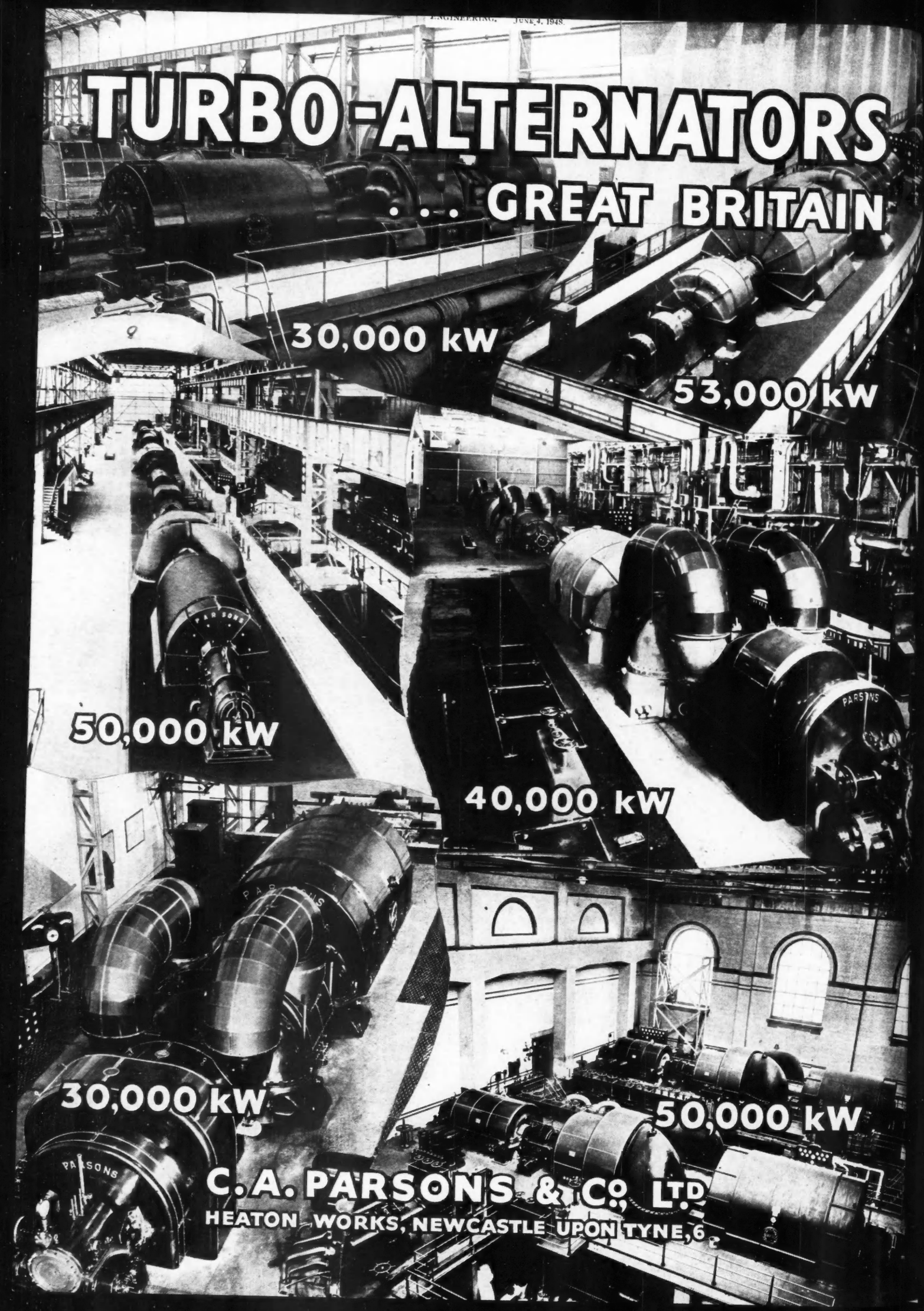
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SOME LESSER-KNOWN TRACTION ENGINES.

By RONALD H. CLARK, A.M.I.Mech.E.

STEAM locomotives still predominate on British railways, but steam traction engines, like steam-driven machine shops, are rapidly disappearing. The traction-engine industry grew and died in a hundred years, and at its height attracted the attention of numerous engineers and firms, examples of whose work are already becoming rare. Two wars and the concomitant calls for scrap metal have removed some notable examples of steam traction engines, and a fine three-speed double-crank compound road locomotive in Fig. 2. Trunk-type crosshead guides were used, and the cylinders were steam-jacketed and fitted with two 1½-in. Ramsbottom-type safety valves. The compound engines worked at 180 lb. per square inch, and the single-cylinder type at 140 lb. per square inch. The main dimensions are given in Table I, herewith; but, if a customer ordered a single-cylinder road locomotive, the bore and stroke were, respectively: 7¾ in. by 9 in. for 5 n.h.p.; 8¼ in. by 10 in. for 6 n.h.p.; 8¾ in. by 12 in. for 7 n.h.p.; and 9¼ in. by 12 in. for 8 n.h.p. "Nominal horse-power" was merely a conventional method of expressing power, the 6-n.h.p. having a cylinder 8 in. in diameter, 7-n.h.p. one of 8½ in. diameter, and 8-n.h.p. one of 9 in. diameter, the stroke usually being 12 in. No account was taken of working pressure, and the brake horse-power was, of course, much higher than the nominal horse-power. However, n.h.p. was a useful measure which was understood by makers and users alike. The position of the high-gear driving pinion is worth noting in Fig. 2. It was placed adjacent to the crankshaft bearing and the low-gear pinion was placed on the outer end of the shaft. Charles Burrell and Sons were the first to introduce this arrangement, arguing that, because the high-gear pinion was used more frequently, it should be supported more favourably than the low-gear pinion. This proved to be sound practice and was copied by other makers. Messrs. Allchin ceased making engines shortly after the 1914-18 war, but, even so, their road-rollers and traction engines are still to be seen in various parts of the country.

The firm of Barrows and Stewart, of Banbury, Oxfordshire—formerly Kirkby and Barrows and then Barrows and Carmichael—were principally concerned with the manufacture of threshing machines and portable steam engines, and only in later years did they turn their attention to traction engines. They used bar guides for the crosshead, Salter-type safety-valves, a three-shaft drive, but

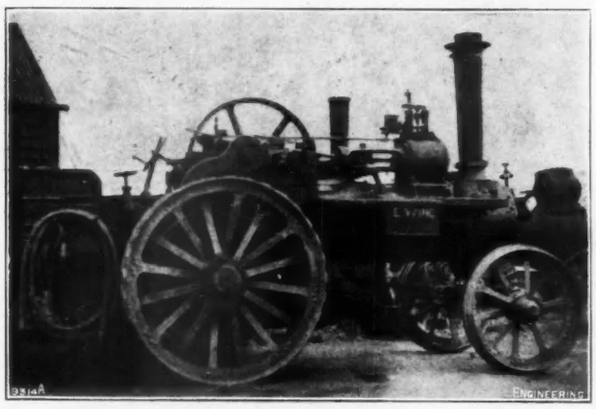


FIG. 1. 6-H.P. ALLCHIN LIGHT TRACTION ENGINE.

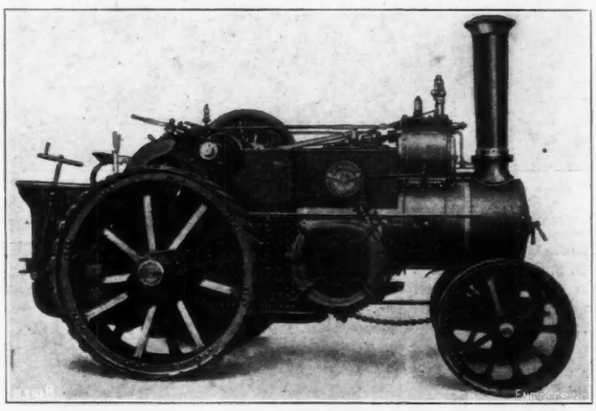


FIG. 2. ALLCHIN DOUBLE-CRANK THREE-SPEED COMPOUND ENGINE.

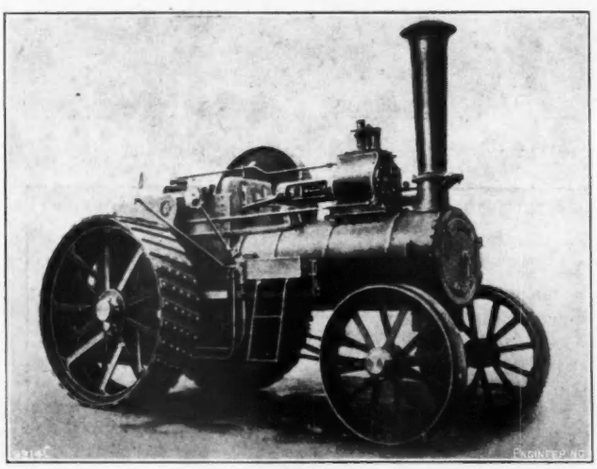


FIG. 3. BROWN AND MAY GENERAL-PURPOSE TRACTION ENGINE.

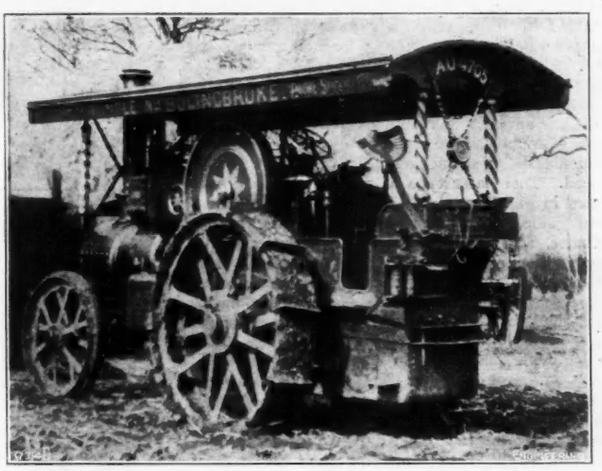


FIG. 4. BROWN AND MAY 5 N.H.P. SHOWMAN'S ENGINE.

and although Mr. F. H. Gillford's articles in ENGINEERING, vol. 135, page 639 (1933), vol. 137, page 477 (1934), and vol. 139, page 431 (1935), gave a useful account of the principal makers and of the history of traction engines, there were several lesser-known makes and types which are worth describing before the opportunity is lost. The firms are treated in alphabetical order of their names as a matter of convenience.

William Allchin and Company, Limited, Globe Works, Northampton, were founded in 1847, and their first engines bore the inscription "William Allchin, Engineer," on the name plates. They did not start making their first self-propelled engines, however, until 1862, when they used a working pressure of 150 lb. per square inch, which was high at that time. Twenty years later, they steam-jacketed the cylinders, and at a later date they adopted compounding. The three-shaft, and later the four-shaft, layouts were used in conjunction with single or compound cylinders and two or three speeds. A light type four-shaft single-cylinder engine of 6 nominal horse-power is shown in Fig. 1,

TABLE I.—MAIN DIMENSIONS OF ALLCHIN TRACTION ENGINES.

—	Single-cylinder Agricultural Engines.				Compound Road Engines.			
N.h.p.	5	6	7	8.	5	6	7	8
B.h.p.	—	28	32	38	—	28	32	38
R.p.m.	—	145	140	140	—	145	140	140
Road speeds miles per hour	—	2 and 4	2 and 4	2 and 4	—	2 and 4	2 and 4	2 and 4
Diameter of cylinder .. in.	7¾	8	8¼	9	5 and 9	5¾ and 9¼	6 and 10	6¼ and 10¼
Stroke of piston .. .. ,,	9	10	12	12	9	10	12	12
Flywheel diameter .. .. ft. in.	—	4 4½	4 6	4 6	—	4 4½	4 5½	4 6
,, width .. .. in.	—	5½	5½	6	—	5½	5½	6
Driving wheel diameter ft. in.	—	5 6	5 9	6 0	—	5 9	6 0	6 3
,, ,, width ,,	—	1 4	1 4	1 4	—	1 4	1 4	1 4
Overall length .. ,,	—	16 2	16 6	17 9	—	16 2	16 6	17 9
,, width .. ,,	—	6 9	7 0	7 3½	—	6 9	7 0	7 3½
Weight empty .. tons cwt.	—	8 10	9 5	10 5	—	9 15	10 5	11 10
,, in working order ..	—	9 15	10 5	11 15	—	11 0	11 10	13 0
Towing load in low gear .. tons	—	28·0	38·0	48·0	—	30·0	40·0	50·0

SOME LESSER-KNOWN TRACTION ENGINES.

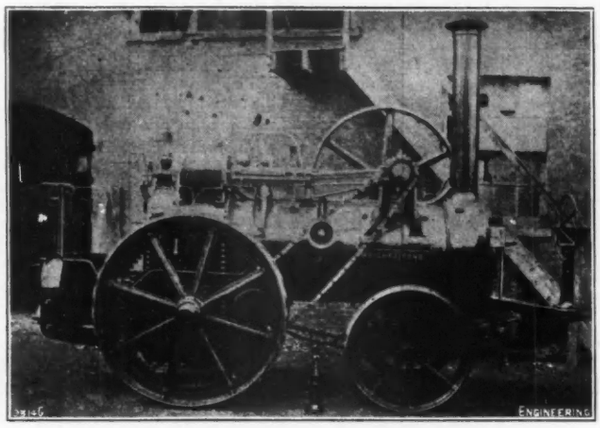


FIG. 5. DODMAN THREE-SHAFT TRACTION ENGINE OF 1872.

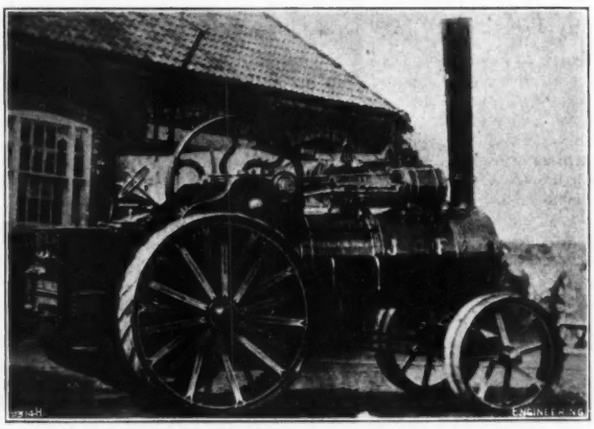


FIG. 6. DODMAN IMPROVED FOUR-SHAFT ENGINE OF 1882.

only one speed. The single cylinder was 9½ in. by 13 in. and the crankshaft 3 in. in diameter. On the main axle was mounted the usual winding drum. The driving wheels were 5 ft. 4 in. in diameter by 1 ft. 2 in. wide, and the front wheels 3 ft. 4 in. by 8 in. The boiler barrel was 2 ft. 8 in. in diameter by 9 ft. 7 in. overall length. There were a few of these engines working in the Fen country until some time during the 1914-18 war, but the writer has not seen any since.

Messrs. Brown and May, Limited,* of North Wilts Foundry, Devizes, Wiltshire, whose business was founded in 1854, were early makers of portable engines which became renowned for their economy in fuel. Their first traction engines had a single-cylinder four-shaft two-speed layout, a tube-cleaning steam-jet, and a spring-mounted footplate. This footplate support was unique and consisted of a casting around the top of the water tank, supporting a number of coil springs on which the footplate was placed. Their later type of traction engine, illustrated in Fig. 3, page 529, had a trunk-type cross-head guide, a slide-valve on the outside of the cylinder, a crankshaft machined from the solid, two speeds, a rear-axle differential which could be locked, a disc-type flywheel and Ramsbottom-type safety-valves. Brown and May's double-crank compound engine of 5 n.h.p., in the form supplied to showmen, is illustrated in Fig. 4, page 529. It had cylinders 4½ in. and 7½ in. in diameter by 8 in. stroke, and a solid-forged crankshaft. Both this engine and their standard 4-n.h.p. single-cylinder "Dreadnought," which was spring-mounted on the rear axle, did not exceed 5 tons unladen weight, thus complying with the Heavy Motor Car Order of 1903. Table II, opposite, gives the principal dimensions of Brown and May's last engines, some of which are still to be found, mainly in southern England, although the firm closed down in 1912.

A small firm whose principal business was the manufacture of some ingenious agricultural implements, but who also turned out three traction engines with several interesting features, was that established by John Collings, near Bacton Hall, at Bacton-on-Sea, Norfolk. He employed probably less than a dozen hands in his little works and foundry, and himself was designer and maker. His No. 1 engine was made in 1900. In placing the duplex cylinders, 3½-in. bore by 6-in. stroke, he reverted to early practice by putting them over the firebox. The valve chests were on either side, which made them conveniently accessible, and each valve was driven by a separate Stephenson link motion. The drive consisted of two pinions (high and low gear) and a dog clutch mounted on a 1⅝-in. diameter crankshaft between the left-hand crankshaft bearing and the flywheel; the counter-shaft was beneath the boiler and carried a five-tooth sprocket on its right-hand end. This sprocket drove the rear-axle sprocket by a chain, 3½ in. in pitch and 1½ in. between side plates. The

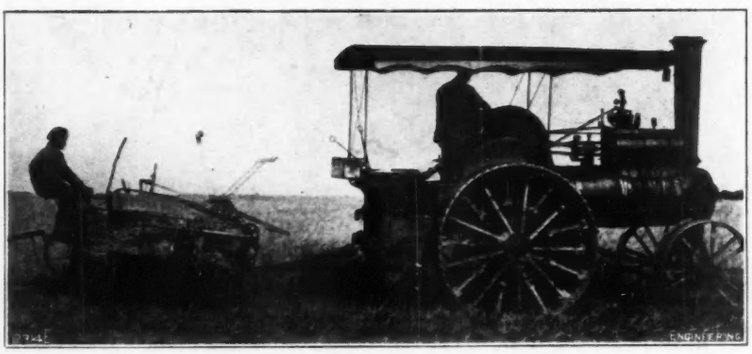


FIG. 7. TANDEM-COMPOUND TRACTION ENGINE BY J. COLLINGS, USED FOR DIRECT TRACTION.

FIG. 8. SINGLE-CYLINDER FOUR-SHAFT ENGINE BY DAVEY, PAXMAN AND COMPANY, LIMITED.

* Messrs. Brown and May had an advertisement in the first issue of ENGINEERING, published on January 5, 1866, describing themselves as "Manufacturers of First Class Portable and Fixed Steam Engines, Two to Forty Horse Power", but made no mention of traction engines. Presumably, this was a later development.—ED. E.

SOME LESSER-KNOWN TRACTION ENGINES.

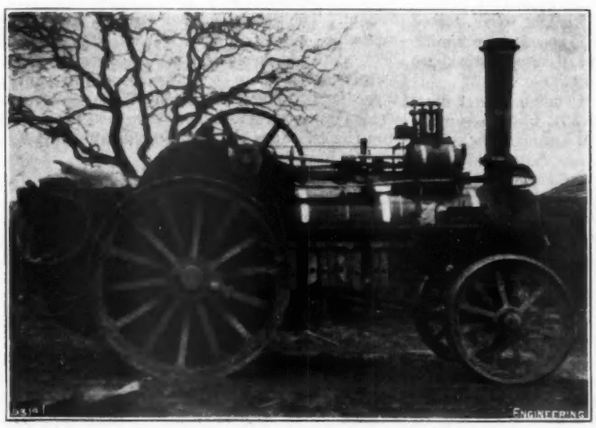


FIG. 9. LATEST DODMAN TRACTION ENGINE WITH ENCLOSED GEAR DRIVE.

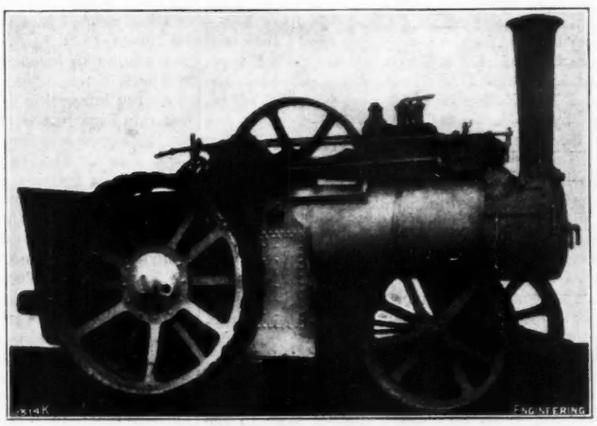


FIG. 10. EDDINGTON AND STEEVENSON'S CONVERTIBLE TRACTION ENGINE.

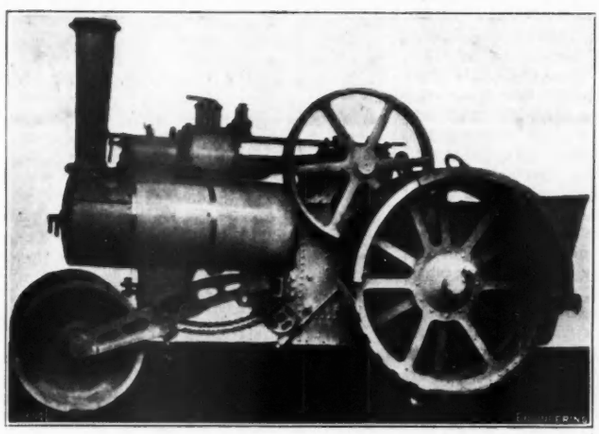


FIG. 11. EDDINGTON AND STEEVENSON'S ENGINE AS ROAD ROLLER.

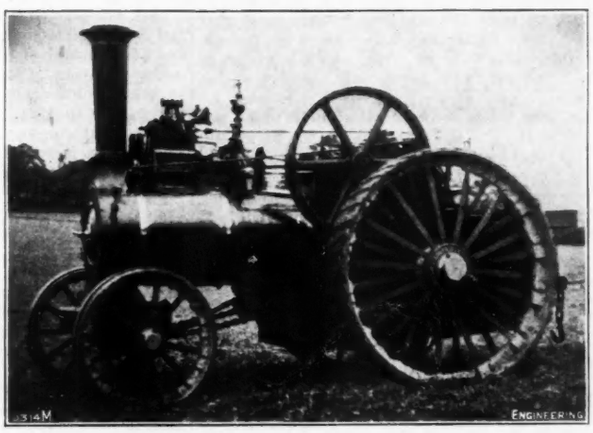


FIG. 12. 7-H.P. FODEN DOUBLE-CRANK COMPOUND TRACTION ENGINE.

TABLE II.—MAIN DIMENSIONS OF BROWN AND MAY TRACTION ENGINES.

	5-Ton Tractors.		Traction Engines.		
N.h.p.	4 Single Cylinder.	5 Compound.	6	7	8
R.p.m.	200	200	175	175	155
Diameter of cylinder ... in.	6½	4½ and 7½	8	8½	9
Stroke of piston ... ,,	8	8	12	12	12
Road speeds ... miles per hour	3 and 5	3 and 5	2½ and 4	2½ and 4	2½ and 4
Flywheel diameter ... ft. in.	3 0	3 0	4 0	4 0	4 6
,, width ... in.	5½	5½	6	6	6½
Driving wheel diameter ... ft. in.	4 9	4 9	6 0	6 0	6 3
,, ,, width ... ,,	1 0	1 0	1 4	1 4	1 6
Front wheel diameter ... ,,	3 2	3 2	3 9	4 0	4 0
,, ,, width ... in.	5	5	9	9	9
Overall length ... ft. in.	12 9	13 4	17 2	17 11	18 3
,, width ... ,,	5 8½	5 8½	6 8	6 8½	7 7
Height to top of flywheel ... ,,	6 10½	6 10½	8 5½	8 7½	9 3

TABLE III.—MAIN DIMENSIONS OF DAVEY, PAXMAN TRACTION ENGINES.

N.h.p.	5	6	7	8	10
B.h.p.	20	24	28	32	40
R.p.m.	180	155	155	155	155
Working pressure ... lb. per sq. in.	160	160	160	160	160
Road speeds ... miles per hour	2 and 4	2 and 4	2 and 4	2 and 4	2 and 4
Diameter of cylinder ... in.	8	8	8½	9	10
Stroke of piston ... ,,	10	12	12	12	12
Diameter of flywheel ... ft. in.	3 6	4 6	4 6	4 6	4 6
Driving wheel diameter ... ,,	5 6	6 0	6 0	6 6	6 6
,, ,, width ... ,,	1 2	1 4	1 5	1 6	1 6
Weight empty ... tons cwt.	7 15	9 5	9 15	10 15	11 5

rear-axle sprocket contained a differential. The flywheel had six spokes and was 2 ft. 7½ in. in diameter by 4-in. face; the rear wheels were 4 ft. in diameter by 11 in. tread; and the front wheels were 2 ft. 8 in. in diameter by 5 in. tread. A Salter-type safety-valve was mounted on the side of the firebox. It was an uncommon example of a chain-driven engine, light in weight, and designed to do the agricultural work now performed by a medium petrol-paraffin tractor. Most of the castings for it were made by G. S. Soame, of Marsham, Norfolk, no longer in business but remembered for having made the first steam engine to drive a roundabout. One of the other two engines built by John Collings is illustrated in Fig. 7, opposite, pulling, by direct traction, two combined reapers and binders, though only one appears in the illustration, for which type of work they were designed to be as light and powerful as possible. They were tandem single-crank compounds with cylinders 5 in. and 8 in. in diameter, by 8-in. stroke, taking steam at 250 lb. per square inch. The boilers were made by Alfred Dodman and Company, Limited, Highgate Works, King's Lynn, Norfolk, or Abbott and Company, Newark-on-Trent.

A firm who took up the manufacture of road engines only at the beginning of the century and turned out a handsome series were Davey, Paxman and Company, Limited, of Colchester, Essex; this firm, however, no longer build steam traction engines. Their standard range of single-cylinder machines is shown in Table III, annexed, and an example is illustrated in Fig. 8, opposite. The four-shaft layout and trunk-type crosshead guide will be noticed. Other interesting features were a planed steel cylinder-seat riveted to the boiler barrel, a trick slide-valve, cast-steel gearing from machine-cut patterns, and the countershaft formed square in section for a part of its length to accommodate the change-speed pinion. Although three-shaft single-cylinder engines were their standard models, Messrs. Davey, Paxman could supply the three-shaft type with single or compound cylinders, the single-cylinder engine, 6-in. bore by 9-in. stroke, being designed for an unladen weight of under 5 tons to comply with the Order of 1903. When driving by belt, the speed was fairly high, being 300 r.p.m., with a flywheel

2 ft. 8 in. in diameter. The firm also built some special engines, including a straw-burning traction engine working at 150 lb. per square inch, with an extra large firebox, a funnel with spark arrester, and a disc-type flywheel on the right-hand side—a very unusual feature; and a fine heavy-duty road locomotive of the double-crank compound type, rated at 7 nominal and 30 brake horse-power, the cylinder dimensions of which were 6-in. and 10½-in. bore by 12-in. stroke. The boiler pressure was 180 lb. per square inch; the road speeds, 3 miles and 5 miles per hour at 180 r.p.m.; the flywheel, 4 ft. in diameter; the rear wheels 6 ft. 6 in. in diameter by 1 ft. 6 in. wide, the front wheels 4 ft. in diameter, and the unladen weight, 11 tons. The cylinders were arranged with the trick valves between them, and with such an arrangement it was not an easy matter to re-face the valve seatings, a fact which many apprentices in country repair shops learned in the hard school of experience. Davey, Paxman engines are still to be found, principally in Norfolk, Lincolnshire and Essex, although the one illustrated in Fig. 8 was in Middlesex.

Situated in an agricultural district close to the sea, Alfred Dodman and Company, of King's Lynn, previously mentioned as boilermakers, built their first traction engine in 1872; it is illustrated in Fig. 5, on page 530. As was customary at that period, the cylinder was placed over the firebox. The interesting form of drive, which is visible in Fig. 5, consisted of a seven-tooth sprocket on the right-hand end of the crankshaft connected by chain drive to the second motion shaft, which was placed in front of the firebox below the barrel and incorporated a differential. Each end of the motion shaft drove a road wheel by means of a 13-tooth pinion engaging with a large annular toothed ring bolted to the inside rim of the road wheel. Chain tension was adjusted by a jockey pulley on a stub shaft supported in a slotted bracket on the side of the boiler barrel. The wheelbase was kept as short as possible by placing the front axle well behind the smokebox to enable the engine to negotiate gateways more readily, and the engine was steered by a handwheel coupled to the front axle by a vertical shaft and side chains, the steersman standing in front of the smokebox door on a platform. At the rear was a footplate with a decorated handrail, to which was fixed a large toolbox. The working pressure was 100 lb. per square inch and the cylinder was approximately 8-in. bore by 10-in. stroke. It was found that the pinions and annular-ring drive were liable to clog with dirt and stones, so Messrs. Dodman brought out an improved engine in 1882, which is illustrated in Fig. 6, page 530. The cylinder was placed at the smokebox end of the boiler to accord with the latest practice, the chain drive was replaced by a four-shaft layout with gears and pinions throughout; and, although the annular toothed rings were retained, the driving pinions were placed as high as possible on the vertical centre line of the road wheels. A deeper tender was fitted, the front-platform steering was abolished, and the workmanship and general finish were of a high order. Several of these engines were working some years after the war of 1914-18.

The last Dodman design, illustrated in Fig. 9, page 531, employed a four-shaft layout with the gears enclosed in sheet-iron covers, which had become the standard practice of all makers at that time. This particular engine was built in 1911 and the original firebox was still in service in 1942. The cylinder was steam-jacketed, the jacket being large enough to form a dome for collecting dry steam. The engine had two speeds, the gears, of cast steel, being splined on to the crankshaft; and the valve-motion links were made of Lowmoor iron, deeply case-hardened and ground-finished. The countershaft incorporated a differential which could be locked from the footplate. The engine could be supplied with a spring-mounted rear axle, if required. The working pressure was 150 lb. per square inch, and the fittings included a whistle and a rear lamp with sliding shutters. These engines were made in 6, 7, 8 and 10-n.p.h. sizes, and it is interesting to note that the price of a 10-n.p.h. engine before 1914 was 595*l*. The 7-n.h.p. engine developed 30 brake horse-power, and had a cylinder 8½-in. bore by 12-in. stroke. The diameter of the flywheel was 4 ft. 6 in., the working speed 155 r.p.m., and the rear wheels were 5 ft. 11½ in. in diameter by 16 in. wide. The overall length was 16 ft. 9 in. and the width 7 ft. 4 in.; the height to the top of the flywheel 8 ft. 10 in., and the speeds were 2 miles and 4 miles an hour. Several of these engines are still used in the eastern counties.

A very interesting design of engine is that illustrated in Figs. 10 and 11, page 531, which was made by Eddington and Steevenson, Limited, of Chelmsford, Essex. The engine could be readily converted from traction to road-roller form, or vice versa. The illustrations show the single-crank tandem-compound model, although it could also be supplied as a single-cylinder machine. The compound cylinders were 6 in. and 10½ in. in diameter by 10-in. stroke. Three speeds were provided on all their engines, giving road speeds of 1½ miles, 2¾ miles and 4 miles an hour.

E. Foden, of Sandbach, Cheshire, started building traction engines in 1882, and although the firm that he founded—E. Foden, Sons and Company, Limited, now Fodens, Limited—discontinued traction-engine building about 1907, they are well known to-day for their motor goods vehicles. Some of their traction engines are still in use. Two examples are shown in Fig. 12, on page 531, and Fig. 13, on page 540.

C. J. Fowell, a former employee of Charles Burrell and Sons, of Thetford, founded the firm of Fowell and Son, Limited, at St. Ives, Huntingdon, in 1876, calling his works "Cromwell Ironworks." The firm built about 102 engines, including a few portable engines, up to 1921. Among his early machines were several single-cylinder engines incorporating Box's patent jackshaft principle. The cylinder was placed over the firebox and the crankshaft near the smokebox end of the boiler, the drive being taken from the crankshaft by spur gears to a cross-shaft (under the boiler barrel), which carried a crank disc at each end. Each crank disc drove a similar crank disc on the rear axle by means of a coupling rod, after locomotive practice, and each rear wheel, being fitted over, and concentric with, the rear crank disc, was driven by a friction band. One of these engines was used in the Eastern Counties shortly after 1918. The engine was illustrated in ENGINEERING, vol. 139, page 563 (1935). Coming to more recent times, one of Messrs. Fowell's engines is illustrated in Fig. 14, on page 340. It was exhibited in 1914 and was one of their series of 7-n.h.p. and 8-n.h.p. single-cylinder three-shaft engines. The design of the chimney, wheels, flywheel, cylinder block, and the position of the low-speed pinion—to mention only a few details—is characteristic of Burrell. The front axle was placed well back to facilitate turning into narrow entrances. The drive was double-geared on the last motion, a locking differential was provided, and all gears were made of crucible-cast steel. The cylinder dimensions were 8½-in. bore by 10-in. stroke for the 7-n.h.p. engine, and 9-in. bore by 12-in. stroke for the 8-n.h.p. engine. The rear wheels were 6 ft. in diameter by 1 ft. 6 in. wide. Engine No. 61, an 8-n.h.p. machine built in 1893, was probably unique because it had an all-welded firebox made in the days before oxy-acetylene and electric welding. It was a considerable achievement to weld a firebox at the blacksmith's fire. These engines were quite economical to operate, many owners doing a day's threshing on 5 cwt. of coal and others hauling 14 tons on 6 cwt. a day. The list price of a 7-n.h.p. engine before the 1914-1918 war was 465*l*. Many Fowell engines are in use to-day. Table IV, herewith, lists all the Fowell engines of which any particulars have been traced.

Some makers, with only meagre plant and machinery, turned out traction engines by buying parts, to a greater or lesser degree, from outside firms. C. J. R. Fyson, of Soham, Cambridgeshire, constructed 17 successful engines between 1894 and 1924 in this way; they are listed in Table V. They were single-cylinder two-speed three-shaft machines, and one of them is illustrated in Fig. 15, page 540. The boilers were made by the Grantham Boiler and Crank Company or by Alfred Dodman and Company, and the leading dimensions were: inside diameter of barrel, 2 ft. 4½ in.; length between tubeplates, 5 ft. 3¾ in.; 36 smoke tubes, 2-in. diameter; working pressure, 140 lb. per square inch. The cylinders, which were 9-in. bore by 12-in. stroke, and the valve gear, were bought from Charles Burrell and Sons. All the other parts were made at the little works at Soham. The flywheels had curved spokes. The method of constructing the rear wheels was unusual, because the spokes fitted into recesses cast in the wheel centres, where they were secured by two ¾-in. taper bolts. The outer ends of the spokes were welded on to the shanks, and were held to the angle-iron rim by three ¾-in. taper bolts with nuts inside the angle. The bolts were driven up tightly with a 4-lb. hammer, and Mr. Fyson has told me that he has never known one to work loose. The usual method is to cast the spoke in at the centre and to rivet the head end to the rim. Bearing present-day costs in mind, it is interesting to note that the labour costs for engine No. T 17, made in 1924, were 416*l*. 19*s*. 1*d*., and the material and other costs were 516*l*. 3*s*. 5*d*., giving a maker's total cost of works 933*l*. 2*s*. 6*d*. Most of these engines are still at work in the Fen country. Mr. Fyson turned out a small portable engine before his first traction engine. It had a single cylinder, and crosshead guides of two solid round bars, 1⅛ in. in diameter. The boiler was hand-riveted at Soham.

Another small firm, who built only two traction engines, were Harvey and Williams, Limited, of Victoria Foundry, Huntingdon. It appears that their cylinder castings were made from patterns borrowed from Fowell and Company; certainly the "family likeness" was apparent. They were single-cylinder engines, 7 and 8 n.h.p., 8½-in. bore by 10-in. stroke and 9-in. bore by 12-in. stroke,

TABLE IV.—*Traction Engines by Fowell and Son.*

Engine No.	Year.	N.h.p.	Remarks.
1	1878	6	
2	1877		
11	1881	8	
18	1882		
19		7	Broken up, 1942.
22	1883	8	
26	1883		Portable engine.
31	1885		Portable engine.
33	1886		
36	1888		
37	1888	8	
38	1888	8	
39	1885		Portable engine.
40	1887		Small marine engine.
44	1889	8	
48	1890	8	
52	1891	8	
53	1891	8	
54	1891		
56			
59			
61	1893	8	Firebox fire-welded.
63	1892		
64	1894		
68	1895		
70	1896	8	
73			Oil engine.
77	1895		
81	1896	7	
83	1896	7	
84		7	
85		7	
86	1897	8	
90	1901	7	
91	1902		
92	1903		
93	1905		
94	1905		
95	1906	7	
97	1908		
98	1909		
101	1911	8	
102	1912	8	
106	1914	8	Show engine.
107	1915		
108	1922	8	
109	1921	7	

TABLE V.—*Traction Engines by C. J. R. Fyson.*

Engine No.	Year.	Remarks.
T1	1894	Gears by Fowell and Son.
T2	1895	
T3	1898	
T4	1900	
T5	1901	
T6	1905	
T7	1906	
T8	1907	
T9	1908	
T10	1909	
T11	1911	
T12	1911	
T13	1913	Rebuilt on new boiler. Other parts ex Robey No. 5187.
T14	1914	
T15	1916	
T16	1921 (Dec.)	
T17	1924 (May)	

respectively. Trunk guides, Stephenson's link motion, two speeds, a three-shaft layout, a differential on the right-hand end of the countershaft, and double-gearing on the last motion, were included in the design. As in the Fowell engine, the front axle was set well back for negotiating stack yards and narrow entrances. The chimney was hinged to the cast-iron base, as is done in portable-engine practice, but no supporting crutch was provided. The boilers were made by Messrs. Harvey and Williams themselves. The valve-chest cover bore the year of manufacture, 1900, together with the makers' name and county. This practice had generally died out ten to 15 years earlier, because date marks, even those cast in relief, could always be altered by unscrupulous vendors of second-hand machines. No date was preferred to a date that could not be relied upon. The writer saw two of these engines at work recently; they were still in excellent condition and a credit to their builders, who worked in a district not usually associated with engineering.

Holmes and Sons, Limited, of Prospect Place Works, Castle-hill, Norwich, won a silver medal for their first traction engine, which was exhibited at an agricultural show in Fakenham, Norfolk, in 1865. From then onwards, various improvements were made, culminating in the straightforward design illustrated in Fig. 16, page 540. They made single-cylinder engines in two sizes, 8 and 10 n.h.p., using a four-shaft drive. The gearing, of cast steel, provided two speeds, of about 2 miles and 4 miles per hour, and a differential was incorporated in the third shaft. The fittings included a winding drum with 60 yards of wire rope, a two-ball pendulum governor, Ramsbottom-type safety-valves, a water lifter, and a feed pump driven off the crankshaft. The list prices of these engines in 1890 were 460*l.* for the 8-n.h.p. engine and 540*l.* for the 10-n.h.p. engine. Messrs. Holmes were well known locally for good stationary engines; several of these are still in use, but the last remaining traction engine was broken up in 1939.

The problem of ploughing by steam engaged the attention of several traction-engine builders during the latter half of the Nineteenth Century, and the "Farmer's Engine," made by J. and F. Howard, Limited, of Bedford, was a machine celebrated for this purpose. The engine, including cylinder, valve-gear, and crankshaft, and two vertical-spindle winding drums, was placed behind the rear road wheels. Two ropes were led forward from the winding drums, under the engine and guided by a pulley at the front end, one rope being connected directly to the plough and the other to a double-drum windlass on the opposite side of the land; the first rope pulled the plough towards the engine and the second rope away from it. The drive from the crankshaft to the rear road wheels and to the winding drums was by spur gearing, and one or the other drive could be engaged by a dog clutch. A steam dome with double Salter safety-valves was fitted on the boiler barrel. The main dimensions of this interesting engine were: cylinders, 8 in. bore by 10 in. stroke; flywheel, 3 ft. 10 in. diameter; 26 smoke tubes, 2¼ in. outside diameter; firebox heating surface, 26½ sq. ft.; tube heating surface, 76½ sq. ft.; grate area, 4½ sq. ft.; tank capacity, 150 gallons; rear wheels, 5 ft. diameter by 1 ft. 4 in. wide; working pressure, 120 lb. per square inch. One of these engines worked in the Fen country for many years, and in 1929 it was run back to the works at Bedford from Burwell, Cambridge, to be preserved. In 1932, however, when Agricultural and General Engineers, Limited, were wound up, the control of J. and F. Howard, Limited, passed to other hands and the old engine was scrapped. There may be one or two left that are not known to the writer. Messrs. Howard ceased to make traction engines some years ago, but they have since been well known for their agricultural implements, particularly ploughs.

Another example of a firm who built engines partly from other makers' parts were Edward Humphries and Company, Limited, of Pershore, Worcestershire. Situated in an agricultural district, they were mainly concerned with agricultural implements and portable engines, but they started to build a range of traction engines after 1890, one of which is illustrated in Fig. 17, page 540. The feed pump and eccentric were standard Aveling and Porter pattern. Single cylinders were fitted to the smaller sizes, 5, 6, 7, 8 and 10 n.h.p., and duplex cylinders to the larger sizes, 12 and 14 n.h.p. The cylinders were jacketed, the gears were of cast steel, a differential was provided on the third shaft, and the engine had two speeds and a winding drum. A 10-n.h.p. engine was priced at 595*l.* Several Humphries engines are still working in the South Midlands. Messrs. Lampit and Company's engines are also to be found in that district. They made engines at Banbury, Oxfordshire, and were competitors of Messrs. Barrows and Stewart, of the same town. They had made a good portable engine in 1867, and all their traction engines were 6 n.h.p., single cylinder, 7½-in. bore by 10-in. stroke, working at 140 lb. per square inch. The rear wheels were 5 ft. 6 in. diameter by 1 ft. 2 in. wide, and a differential and rope-winding drum were included. The drive was built on the three-shaft and four-shaft principle, that is, three shafts were used in high gear and a fourth shaft with gearing was engaged for low gear. With this layout, the driver had to remember that, when changing from high to low gear, the fore gear became the back gear and vice versa, and the reversing gear had to be operated accordingly.

Mann and Charlesworth, Limited, of Hunslet, Leeds, made a number of single-cylinder three-shaft 7-n.h.p. engines with Joy's valve gear, an unusual feature and the only application of this gear to traction engines known to the writer. They were well-proportioned compact engines, with jacketed cylinders, a balanced crank, two speeds, and steering on the left-hand side. Several of these engines are still at work, notably in the Peterborough area. The name of the firm was later altered to Mann's Patent Steam Cart and Wagon Company, Limited, after which they produced a light tractor of less than 5 tons unladen weight. It was supplied with compound or single cylinders and worked at 200 lb. per square inch. The example illustrated in Fig. 18, page 540, was fitted with a belly tank for long-distance work and direct worm-geared steering. The four driving-pin holes in the bosses of the rear wheels were a characteristic feature of some Mann and Charlesworth engines, although not all were thus provided. The high-pressure cylinder and winding drum were fitted on the right-hand side. Rolling contractors converted several of these engines to road rollers by fitting boiler plate over the rear wheel rims and pivoting the front roller about a saddle made from a curved piece of plate fastened to the smokebox.

It may be noted here that Messrs. Petters, Limited, of Loughborough, Leicestershire, now known for their oil engines, turned out a number of 5-n.h.p. single-cylinder three-shaft engines at their works at Yeovil, Somerset.

(To be continued.)

LITERATURE.

Sewerage Design and Specification. By L. B. ESCRITT, A.M.I.C.E. Published by *The Contractors' Record and Municipal Engineering*, Lennox House, Norfolk-street, London, W.C.2. [Price 30*s.*]

To those who are concerned with the siting, proportions and construction of sewers, the name of Mr. L. B. Escritt is already familiar, for this present study is by no means his first venture into authorship. Like its predecessors, it is essentially a practical book, making full use (with appropriate and unfailing acknowledgment) of earlier writings and records, official publications, etc.; but always with a personal judgment and insight which makes of the resultant work something much more than a mere compilation. Starting with a survey of the general principles of sewerage, it proceeds to deal in successive chapters with sewers for soil and surface water, and with land drainage and river works; then with the detailed design and construction of sewers, and their flushing and ventilation; and, finally, with surcharge conditions, inverted siphons, pumping schemes, and the sewerage of coastal towns. "Finally" is, perhaps, something of an under-statement, for there are four appendices, an extensive bibliography, an index and ten pages of advertisements after the last chapter of the text. We have criticised before the practice of incorporating trade advertising matter in text-books and will not elaborate upon the matter otherwise than to express the opinion that the paper thus used might have been expended more usefully, from the reader's point of view, by providing, in a pocket, separate and much larger versions of the diagram, on page 283, for calculating the sizes of surface-water sewers according to the Lloyd-Davies method. The head-quantity curves of axial-flow pumps, on page 244, are also difficult to read; but it should be added that these cases are exceptional, the general quality of the illustrations being particularly good.

Design This Day. By WALTER DORWIN TEAGUE. The Studio Publications, Limited, 66, Chandos-place, London, W.C.2. [Price 35*s.* net.]

THE extent to which Art, with a capital A, should be consciously permitted or encouraged to enter into the design of engineering structures is obviously a matter of opinion, though it will be generally conceded that some recognition of the principles of artistic proportion is advantageous, provided that the purely "functional" requirements are not prejudiced thereby. Hitherto, such æsthetic merits as attach to modern engineering structures seem to have been accidental more often than not; Mr. Teague seeks to show that this need not be so, and that a due attention to ultimate appearance can not only enhance the appeal of a purely functional machine or structure, but may also reconcile public opinion to the inevitably obvious presence of such technical products in centres of community life. This does not necessarily involve designing a power station to look like a cathedral, but it does emphasise the point that ugliness is not inherently associated with utility and that a little expenditure of thought and money in avoiding ugliness may be well worth while. Though one impression conveyed by Mr. Teague's book is that some of the examples illustrated owe a great deal to the skill of the photographer, a study of its contents should serve to reinforce strongly the arguments put forward in the course of lectures on "The Aesthetic Side of Civil Engineering Design," arranged by the Institution of Civil Engineers some three years ago and discussed editorially on page 412 of our 159th volume (1945). At the same time, there are passages in the text which are a warning against the danger that too intense a study of the æsthetic side of design, rather than of practical considerations, may cause the enthusiast to cloud his own mental vision with a profusion of words. It should be possible to construct a building that is artistically satisfying without worrying whether "modern materials and techniques can be made to provide rhythmic accents to the major form."

INSTITUTE OF TRANSPORT SCHOLARSHIPS.—The Council of the Institute of Transport have awarded Henry Spurrier Memorial Scholarships, for 1947-48, to Mr. Ralph Cropper, of London, and to Mr. A. J. Dale, of Stoke-on-Trent; the Silver Jubilee Scholarship to Mr. R. L. F. Woodhouse, of Dublin; and the Sir William Chamberlain Memorial Scholarship to Mr. W. J. Antonia, of Manchester.

SHEFFIELD METALLURGICAL ASSOCIATION.—Last year the lectures delivered before the Sheffield Metallurgical Association covered such subjects as "Aspects, other than Metallurgical, of the Steel Industry," by Mr. F. Pickworth and "The Trade and Commerce of Sheffield," by Colonel F. A. Neill, C.B.E., D.S.O., as well as many branches of metallurgy. A glance through the report of the Association for 1947, which has just come to hand, gives some indication of the wide range of the Association's activities, and among the useful features of the report are the summaries given of the lectures delivered and papers presented during the year. Several social events have been held in addition to the business and scientific meetings. Tribute is paid to the services rendered by Mr. L. Rotherham, M.Sc., F.Inst.P., during his tenure of the office of secretary for eight years. Mr. Rotherham left Sheffield at the beginning of 1947 to take up duties at the Royal Aircraft Establishment, Farnborough. The list of past-presidents is headed by the name of the late Dr. W. H. Hatfield, F.R.S., who served in 1918; hence 1948 is the 30th year of the Association's existence.

RADAR NAVIGATIONAL AID FOR LIVERPOOL.

AN important contribution to the safety of navigation by the use of Radar is provided by an installation, which has been designed for the Mersey Docks and Harbour Board, Liverpool, by the Sperry Gyroscope Company, Limited, Great West-road, Brentford, Middlesex, in collaboration with Messrs. Cossor Radar, Limited, Highbury-grove, London, N.5. The object of this installation, which we had opportunity of inspecting at the maker's works on Friday, May 21, and which is shortly to be erected at the Gladstone Dock, is to enable the shore authorities to ascertain the situation of the shipping in the approach channel and the River Mersey during fog; and to convey this information to the masters and pilots of both incoming and outgoing vessels. It is thus hoped, by its use, not only to avoid the risk of collisions, but to prevent the delays which occur at present owing to the necessity during fog of anchoring in the approach channel or to difficulty of leaving the port. In the case of ships already fitted with Radar equipment it will form an additional safeguard, as although it is now possible for them to proceed with safety as far as the Bar Light Vessel at the entrance to the estuary their further progress may be prevented by the weather conditions. Another advantage of the installation is that it will enable obstructions in the channel to be observed and the necessary warnings to be given. It can also be used during foggy weather to assist the pilot to pick up a ship approaching the port and to aid vessels in the calibration of their directional wireless equipment.

To meet these requirements it was first necessary to make a careful study of the conditions on the site. Work on this investigation began in the spring of 1946, when a mobile 3-cm. Radar equipment with a bearing discrimination of about 1½ deg. and a range discrimination of 150 yards was made available by the Admiralty. This equipment was installed on the top of a warehouse near Gladstone Dock, at the entrance to the harbour proper, where a good view of the approach channels was obtainable. As, however, some 14 miles of approach channel had to be compressed into a display of 4 in. radius on the plan position indicator (P.P.I.) accurate reading was almost impossible with this apparatus. Even when a 5-in. "B" scope display was substituted the clarity of the picture was not good enough. In addition, the picture was distorted, so that it was difficult to recognise the shape of the channel, these unsatisfactory results being chiefly due to the inadequacy of both the bearing and range discriminations. An investigation into the precise requirements for an equipment which would provide really effective supervision, was therefore made by the Sperry Company, in collaboration with the Mersey Docks and Harbour Board, and the Admiralty. As a result it appeared that, as the approach channel was 14 miles long and both tortuous and narrow, the discrimination should be better than 1 deg. in bearing and by about 40 yards in range. It was also essential that the displays should be on a scale of about 1 in 30,000 to 40,000. Moreover, owing to the high shipping density, it was necessary to be able to differentiate between the echoes from buoys and vessels, and for a single non-technical operator to fix the positions of the latter quickly and with accuracy. Simplicity in operation, great reliability in use and easy maintenance were other essentials. It is claimed that the equipment, which is a slight modification of the Cossor marine Radar apparatus, fulfils these conditions, although as it is still under development it is not possible to publish a full description of its design.

Like the experimental installation, the permanent equipment will be installed at the north-west corner of Gladstone Dock, where an unrestricted view of the estuary is obtainable as far up river as the Prince's landing stage and down river of the whole of Liverpool Bay. The Radar and communication equipment, as well as the necessary power plant on this site, will be housed in a special building, alongside which an 80-ft. reinforced-concrete tower has been built to carry the scanner or aerial. This aerial, which has a span of 15 ft., has been erected for test purposes on the roof of the Sperry works and its appearance in that position, as well as of its driving mechanism, which is situated below it, will be understood from Fig. 1. It has been designed to give a bearing discrimination of ¾ deg., special care having been taken to minimise the effects of "side lobes" which might give rise to spurious signals on false bearings. It has also been designed to be capable of rotation in winds up to 100 m.p.h., and is fitted with heaters so that it will not ice up during cold weather. On site, the electric driving mechanism which rotates the scanner at 12 r.p.m. will be housed in a room at the top of the tower, thus rendering it more accessible for maintenance than if a cast pedestal had been used.

Signals will be transmitted from this scanner on a wavelength of 3 cm., and during its 5-second rotation an echo will be obtained from every object within a radius of 20 miles. These echoes will be displayed on six plan position indicators mounted on a console in the control room, where the transmitter and receiver units, the synchroniser units, power packs and monitoring equipment will also be housed. A view of this console in course of construction is given in Fig. 2. Of the six displays, the first will show a small-scale view of Liverpool Bay from the Bar Light Vessel at the entrance to slightly above Gladstone Dock. Normally its range will be 13 miles, to a scale of 1 in. to the nautical mile, though it can also be adjusted to give a range up to 20 miles to a scale of ½ in. to a mile. Four other displays will each show a scale view of part of the channel from the Bar Light Vessel up to well above the Prince's Landing Stage. They will each be set up to a scale of 2 in. to the mile, and will slightly overlap. The result will be an uninterrupted view of the area of a much larger size than could be accommodated on a single cathode-ray tube. The displays themselves are of a new type and will give a precision picture of the appropriate part of the channel with true plan presentation. They will have charts of the corresponding parts of the channel in front of them on which all buoys and other navigational marks will be indicated. Identification of the echoes from these objects will therefore be rapid and will be assisted by the provision of a rectangular grid. It will thus be possible to read the reference of any echo directly and to plot it on a chart. In this way, it is claimed, it will be possible to fix the position of a vessel more rapidly than if range and bearing indications were used or if range and bearing had to be plotted on a chart before the "fix" could be made. This rectangular grid reference, when desired, can be connected directly to any vessel requiring a "fix." The sixth display, which is known as the "wandering display," will enable any area within 20 miles, which is not shown on the four pictures forming the mosaic of the estuary, to be examined at will. The apparatus associated with each display is mounted on carriages, so that it can be withdrawn from the console and a spare wheeled into place to simplify servicing.

In the initial installation the information obtained about conditions in the estuary will be displayed only on the plan position indicators in the control room and will be transmitted to the Port Authority's office by telephone. The equipment, however, has been designed so that this information can be transmitted by radio link to other displays without it being necessary to scrap equipment already installed.

In operation it is intended that the information regarding navigational conditions obtained on the plan position indicators shall be transmitted to the pilots or masters of the vessels in the estuary, who will carry portable sets. These will thus be in continuous communication with the Radar station during low visability conditions. It must, however, be stressed that they will be provided with information only and that no attempt will be made to deprive them of the responsibility of conning and manœuvring the ships of which they are in charge. It would further appear that a careful "drill" will have to be worked out to prevent any confusion that might arise in distinguishing between messages intended for particular ships. Generally speaking, moreover, the displays will have to be arranged to suit the length of the approach channel and other geographical features at a particular port.

RADAR EQUIPMENT FOR LIVERPOOL.

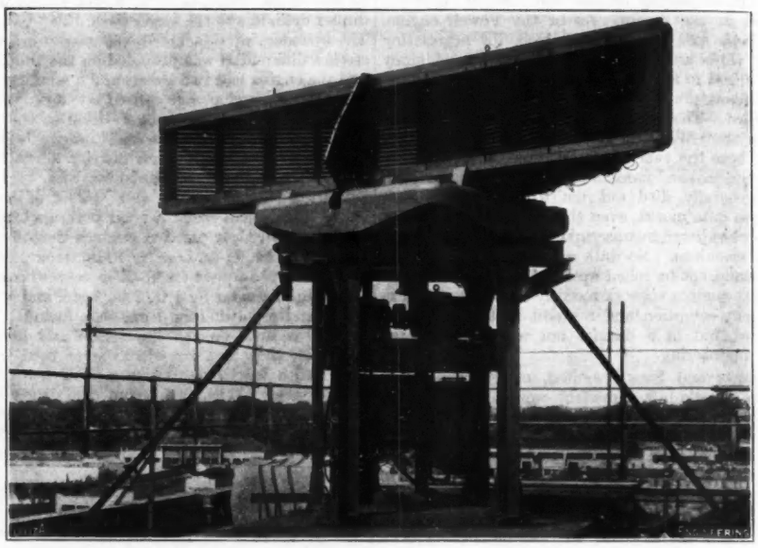


FIG. 1. SCANNER AT MAKER'S WORKS.

FIG. 2. PLAN-POSITION INDICATORS UNDER CONSTRUCTION.

THE COLD WELDING OF METALS.

THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

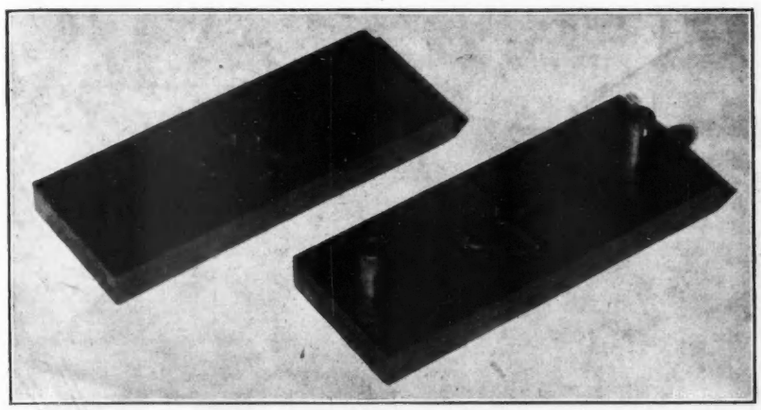


FIG. 1. DIE FOR MAKING JOINT IN STRIP METAL.

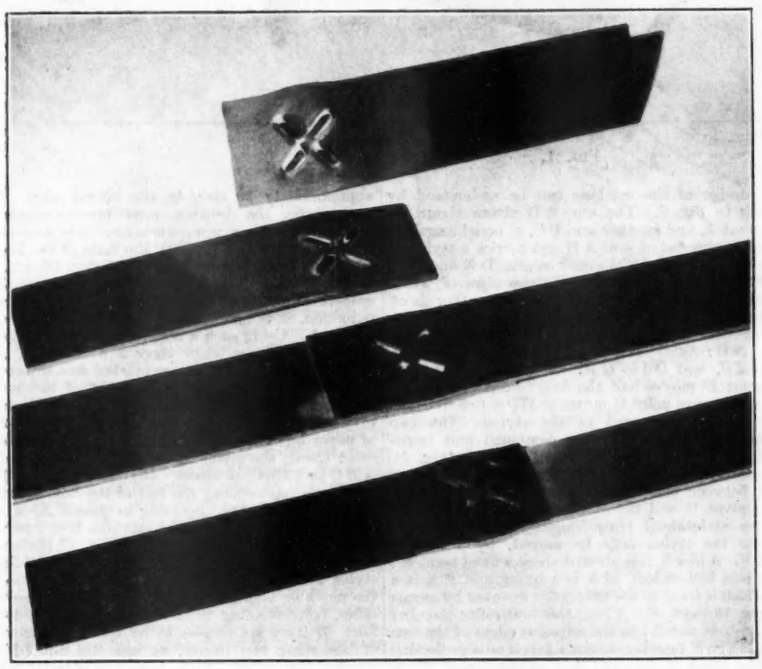


FIG. 2. STRIP JOINTS AND FRACTURED TEST-PIECE.

THE COLD WELDING OF METALS.

RECENT developments made in the General Electric Company's Research Laboratories, Wembley, Middlesex, show that aluminium, some aluminium alloys and various other metals can be cold-welded easily and effectively provided that the metal is given a suitable preliminary surface treatment. Briefly, the process consists in applying pressure to the work pieces to be joined, by means of specially-designed dies. The application of pressure not only brings the two surfaces into close contact but also causes flow to take place, with the result that the two pieces of metal become welded together. Cleanliness of the surfaces to be welded is of the utmost importance, and another essential is that the pressure must be applied over a comparatively narrow strip and in such a manner that the metal can flow away from the weld on both sides; in fact a considerable displacement of metal is necessary for a good weld to be obtained. A die which has proved satisfactory for making joints in strip metal is shown in Fig. 1, and the resulting joint between two strips of commercial aluminium, made with the aid of a hydraulic press, is seen in the centre in Fig. 2. With some dies, hand-operated presses are also employed. The dies used for welding commercial-purity aluminium, so far, have been made of mild steel. A chromium-manganese tool steel has also been found suitable and there is no need for this to be hardened. The only pick-up of material by the dies observed is a slight surface contamination almost equivalent to a thin plating. Die wear does not seem likely to be troublesome as there has been very little wear even in dies which have been used extensively. The pressures required are related to the area of the dies, but are generally only slightly above the flow point of the metal, and, for aluminium, are from 12 to 18 tons per square inch. The time during which the pressure is applied does not appear to be critical and good welds can be made with tools giving either a slow squeeze or an impact.

The method of preparation of the work surface is of importance, it being essential that there should be direct and intimate contact between the surfaces to be welded. All surface contamination must be removed, including the film of oxide which is to be found on the surfaces of most metals and particularly on those of aluminium and its alloys. Moreover, this cleaning must be done by a method which does not leave debris behind on the prepared surface. Chemical methods of cleaning are unsuitable as, almost invariably, they need to be followed by washing, by which the oxide film is reformed. Filing and treatment with abrasives are also unsuitable. It has been found that consistently good welds are obtained by using a power-driven rotary scratch brush. Steel-wire brushes having a surface speed of about 3,000 ft. per minute have been found to be the most satisfactory. The brush must be in contact with the work long enough to make the "drag" felt, thus indicating that the steel wires have broken through the oxide film and are seizing on to the metal surface below. The speed of rotation of the brush ensures that the dust is thrown clear of the work and a dust-free surface results. In some instances aluminium-alloy sheet and strip as received must be degreased prior to scratch-brushing.

The mechanism of cold welding is still the subject of research but it is pointed out that it can be compared with the blacksmith's method of welding iron. In that process the metal is heated and thus made plastic so that it will flow when further worked by pressure or hammering. Moreover, the temperature at which the flow and welding take place promote recrystallisation in the material at the joint. Ductile metals can be made to flow when cold by the application of sufficient pressure, and the conditions may be such that recrystallisation takes place at room temperature. In cold welding the material is hardened by the work which is put into it, and this is considered to be an advantage, as though the cross-section of the work is usually decreased, the loss in strength is counterbalanced to a certain extent by the hardening. Satisfactory welds are produced only when the combined thickness of the parts to be welded is reduced by a certain minimum percentage which is a characteristic of the materials to be welded. For convenience, a "figure of merit" has been used to compare the weldability of different materials and this is expressed as the maximum percentage of the double thickness which can remain when a good weld has been made. Table I gives this value for a number of materials which have been tested at the Wembley Laboratories. From this table it can be

TABLE I.

Material.	Figure of Merit.
Aluminium (super-purity)	40
" (commercial purity)	about 30
Aluminium alloy DTD 346	29
" " BA 60 A (1·25 per cent. Mn)	20
Duralumin	20
Cadmium	16
Lead	16
Copper	14
Nickel	11
Zinc	8
Silver	6

seen that the most satisfactory applications are likely to be made with aluminium and its alloys and copper. The remainder of the materials are not likely to be much used except where strength is not important. With regard to aluminium alloys it is interesting to note that not more than 3 per cent. of manganese or silicon can be tolerated if a satisfactory cold weld is to be made, and that heat-treatable alloys, such as Duralumin, can be cold-welded in the soft condition and then allowed to harden in the usual manner. Another matter of interest is that by employing special dies the two components of which have different surface areas, strips of copper have been cold-welded satisfactorily to strips of aluminium and it is stated that the resultant weld is practically as strong as an all-aluminium weld. An example of a cold weld between a strip of copper (on the left) and a strip of aluminium (on the right) is shown in the lower part of Fig. 2.

The strength of a weld clearly depends upon its shape, and, by judicious design of the dies used, bearing in mind the decrease in thickness at the points where pressure is exerted and the effect of work hardening, it is generally possible to arrange that the joint is practically as strong as the original section. Thus strip which we saw pulled at the Wembley Laboratories failed under a total tensile load of 1·7 tons; the load required to fracture similar unwelded strip, we were informed, is 1·8 tons. The fracture of the welded strip takes place across the flowed metal, indicating that the weld is sound. A weld fractured in a tensile test is shown in the upper part of Fig. 2; the metal pressed by the dies has been sheared through, but there is no sign of any pulling apart.

In addition to welds of the type shown in Fig. 2, ring welds, whereby aluminium tubes may be sealed, can also be produced. Concentric cylindrical steel dies are employed and these are made to press circumferentially an aluminium disc on to the end of the tube. Continuous seam welds are also made and tubes for conduits or other purposes can be produced in this manner. Aluminium sheet is cut to width and formed into a cylinder with the matching ends protruding radially, thus forming external parallel longitudinal flanges. These two flanges are then cold-welded by being pressed together between rollers in a machine which also trims off the excess metal.

"PERSPECTOR" DRAUGHTING MACHINE.

ISOMETRIC PROJECTIONS, LIMITED, NEWPORT PAGNELL, BUCKINGHAMSHIRE.

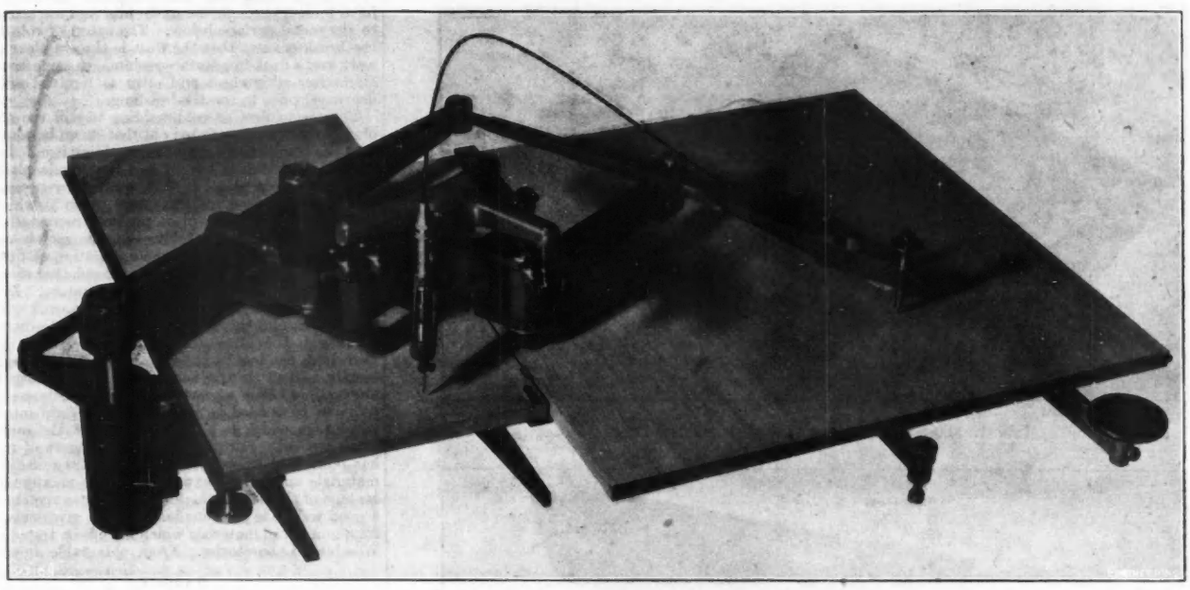


FIG. 1.

ISOMETRIC-PROJECTING PANTOGRAPH.

THE pictorial representation of machines and components, in isometric, perspective, and other forms, has been widely adopted in industry, such methods being particularly valuable for imparting information to the many persons who have not been trained to read machine drawings. It is, however, a skilled and expensive task to prepare the drawings, and usually it can only be justified for such publications as parts lists, instruction manuals, etc., which are issued in large numbers. The time required to prepare these drawings has now been reduced considerably by the introduction of a hand-operated machine known as the Perspector Model A, which is illustrated in Fig. 1, on this page, and for which world patents are pending. It is designed on the principle of a pantograph and is made by Messrs. Isometric Projections, Limited, The Green, Broad-street, Newport Pagnell, Buckinghamshire, who also undertake the preparation of drawings, using the Perspector, on behalf of customers who have not sufficient work of this type to justify the purchase of a machine.

A plan view of the Perspector is shown in Fig. 2, opposite. The operator stands with the fixed drawing board, *a*, in front of him. The handwheel, *b*, is then to his left, and, by turning it, he can traverse the movable drawing board, *c*, to the right or left. The engineering drawing of the component to be projected is pinned to the fixed board, a plain sheet of paper is pinned to the movable board, and by following the original drawing with the stylus of the Perspector, in accordance with certain rules, an isometric, or other type of pictorial, drawing is reproduced on the paper by the movements of a pencil in the machine. The arrangement and proportion of the levers and links of the machine are such that a longitudinal movement of the stylus (towards or away from the operator) is copied by the pencil, which, however, only moves half the distance. When the stylus is moved laterally, from left to right, or vice versa, the pencil also moves from one side to the other, but it only travels cos 54 deg. 44 min. multiplied by half the distance, *i.e.*, it moves $0{\cdot}577 \times 0{\cdot}5 = 0{\cdot}289$ of the distance. It is apparent, therefore, that if the stylus is moved round a circle, an ellipse will be produced by the pencil; the major axis will be half the diameter of the circle, and the minor axis will be 0·289 of the diameter. The ratio of the minor axis to the major axis will be 0·577 : 1, and, as this is the form of ellipses in the planes of isometric drawings, the Perspector may be used for producing isometric views. By traversing the movable board, the operator can draw outlines, ellipses, etc., in any number of planes. An isometric, partly-sectioned, drawing of a gearbox body, which has been prepared with the aid of a Perspector in approximately six hours is reproduced in Fig. 3, opposite.

The design of the machine can be understood by referring to Fig. 2. The arm A B pivots about the fixed point A, and another arm B C, of equal length, is pivoted to the end of arm A B and carries a stylus at the end C. Two links of equal length, D E and E F, complete a parallelogram linkage the sides of which are exactly half the length of A B. Two other links, G H and H J, are attached to the arm A B and link D E, so that A G = cos 54 deg. 44 min. × A D = 0·577 A D; and D J = 0·577 D E. Obviously, G D = H J, and D J = G H. It will be seen, then, that point E moves half the longitudinal movement of the stylus, and point H moves $0{\cdot}577 \times 0{\cdot}5 = 0{\cdot}289$ of the lateral movement of the stylus. The two motions, and none other, are combined and transmitted to a pencil by a Y-shaped member (Fig. 1), which carries two bars in the form of a T, each bar rolling between sets of rollers which are supported, one on pivot H and the other on pivot E. The two bars are maintained truly longitudinal and lateral, wherever the stylus may be moved, by a linkage K L M N. A link K L is pivoted about a fixed point K; L D M is a bell-crank; M N is a link; and E N is a lever which is fixed to the four-roller member by means of a pin through E. Thus, the four-roller member is always held parallel to the adjacent edges of the two boards. The Y member carries a pencil on a projecting lug. The pencil is normally held off the board, but is brought down on to it whenever the operator presses a button on top of the stylus. The connection is by means of a Bowden cable, and the pressure of the pencil is independent of the pressure exerted by the operator, although it may be varied by adding small weights. As, however, some operators tend to apply more pressure than others, the resistance offered by the button, due to a spring, can be adjusted by means of a knurled screw.

The Perspector is of very sound design and construction. The principal members are of RR50 alloy, and the pivots are fitted with Hoffmann ball bearings. The whole is supported by a frame which is intended to stand on a table or bench 26 in. high. The movable board slides on a flat track, and rolls on two balls in a grooved track. It is connected to the handwheel spindle by two fine wires, and a ratchet device enables the operator to obtain a series of small movements of the board for drawing such details as threads, annular grooves, etc. The Perspector has been designed to maintain a high degree of accuracy—certainly more accurate than a pencil point—although it may sustain comparatively rough usage.

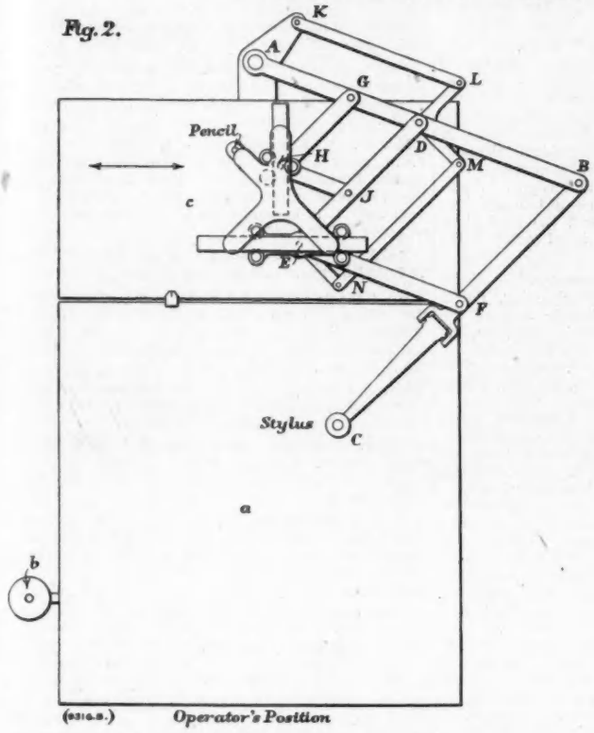
The method of obtaining an isometric drawing is illustrated by Fig. 4, opposite. For clarity, the half reduction produced by the Perspector is not shown. The ordinary plan-and-elevation drawing is pinned to the large fixed board so that the horizontal and vertical centre lines are at exactly 45 deg. to the edges, and a plain sheet of paper is pinned to the movable board at approximately 30 deg. to the lateral edge. Before commencing the drawing, some measurements must be taken, using an isometric scale. For lines such as A B, B C, C D, D A (Fig. 4), the ratio of the isometric length to the true length is cos 35 deg. 16 min. : 1 or 0·816 : 1. As, however, the Perspector makes a reduction in size of 0·5, in addition to the isometric reduction, it is necessary to use an isometric scale of 0·408 : 1. Using such a scale, the isometric distances between all planes where there is a change of section (W, X, Y and Z in Fig. 4), are marked on a slip of paper, which is then clipped to the edge of the movable board, as indicated in Fig. 4. The actual drawing may now be commenced. With the W mark on the slip of paper brought into line with the index mark on the fixed board, the stylus is traced around the elevation A B C D. This produces the isometric A B C D. The circle representing the end of the hole is similarly projected. All lines appearing in planes X, Y and Z are then projected, with the movable board moved to its appropriate position in each case. "Horizontal" lines in the isometric view are drawn by holding the stylus over the correct position on the elevation while the movable board is traversed from one plane to another, corresponding to the beginning and end of the line. If there are ellipses to be drawn in one or both of the other two planes, as was the case with the drawing shown in Fig. 3, both the original and the isometric drawings must be re-pinned in the appropriate positions on the boards. The thin lines in Fig. 3, which were projected with the aid of the Perspector, represent the boundaries of fillets and rounded corners, and can be used as a guide to hand shading, if this is required. In the example shown in Fig. 4, it is not necessary to have a plan of the object. Sometimes, as with simple bushes, etc., no drawings are required—an operator can work from given dimensions.

Although the basic principles have been described, it will be appreciated that each drawing has to be treated on its merits, and an intelligent draughtsman will soon determine the quickest method to be adopted in each case. We have described the Perspector as an isometric-projecting pantograph. That is certainly its primary function, but it can also be used for presenting pictorial views from other angles, within certain limits. If, for example, the original drawing and the blank sheet of paper are pinned to the board with their edges parallel to the edges of the board, the Perspector will project a pictorial view in which the top and bottom faces of the block (Fig. 4) will appear as straight lines, and the centre-line through the hole will be horizontal. The end of the hole, however, will still appear as an ellipse of isometric proportions (due to the pantograph); and the face A B C D will be represented as though it were at an angle of 54 deg. 44 min. to the plane of projection (cos. 54 deg. 44 min. = 0·577). In general, the Perspector may be used to project an object in an infinite variety of positions in relation to

"PERSPECTOR" DRAUGHTING MACHINE.

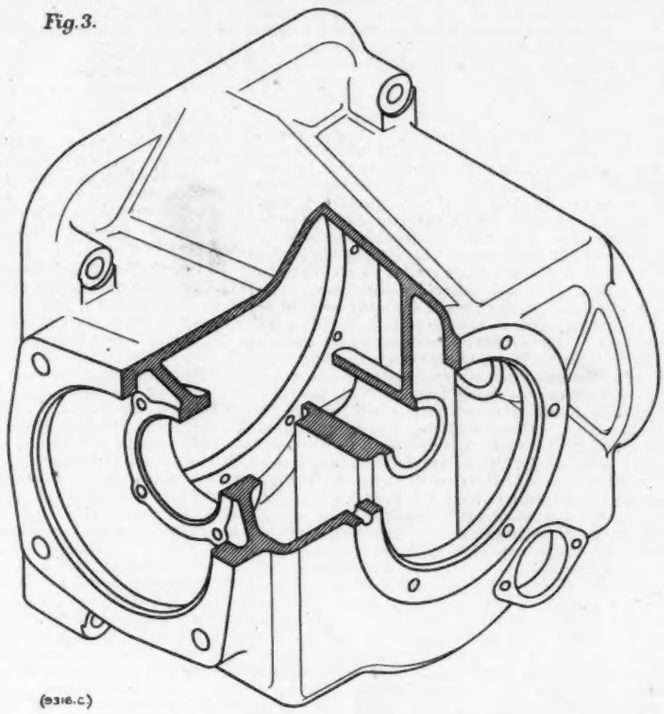
ISOMETRIC PROJECTIONS, LIMITED, NEWPORT PAGNELL, BUCKINGHAMSHIRE.

Fig. 2.



(9316.B.) *Operator's Position*

Fig. 3.



(9316.C)

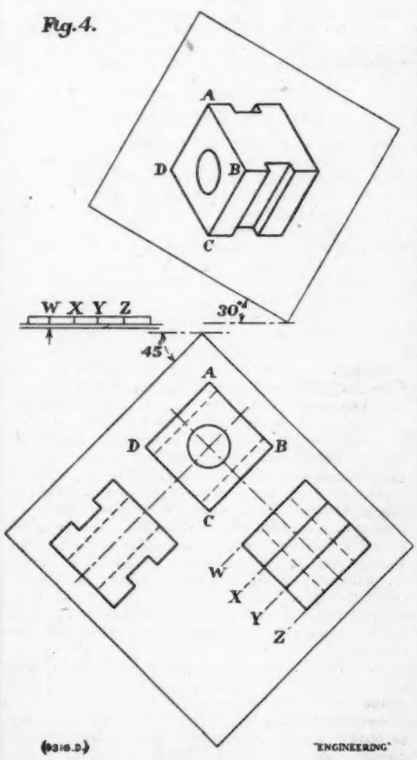
the projecting plane, always provided that one principal plane of the object is represented as being at an angle of 54 deg. 44 min. to the plane of projection, or, to express it another way, provided that one principal centre-line of the object is represented as being at an angle of 35 deg. 16 min. to the plane of projection. An isometric view is simply the special case in which all three principal planes are at an angle of 54 deg. 44 min. to the plane of projection.

To obtain a view other than a true isometric view or the view in which one centre line is horizontal, it is only necessary to pin the original drawing to the fixed board at any angle between 0 and 45 deg. to the edges. In practice, this affords a wide choice of positions, since any one of the three planes of an object can be represented as being at an angle of 54 deg. 44 min. to the plane of projection. Furthermore, an object may be viewed from "on top" or from "underneath." Although the Perspector is primarily intended for the type of drawings we have described, it can also be used for true perspective drawings, in which parallel lines are shown tapering towards a vanishing point. A grid-type scale must be constructed, to give the appropriate scale for each plane.

We have deliberately refrained from using words such as orthographic and axonometric, because they are used in different senses in British and American books. In this country, orthographic generally means the conventional plan and elevation type of drawing, whether it is first- or third-angle projection. According to at least one American book,* however, orthographic embraces all drawings in which the imaginary projecting lines (projectors) are parallel to each other, and normal to the plane of projection. The object itself may be in any position in relation to the plane of projection; if its principal centre-lines and faces are parallel or normal to the plane of projection, and several views are drawn, first-, second-, third-, or fourth-angle projection is produced. If the principal centre-lines and faces are not parallel or normal to the plane of projection, the drawing is an axonometric projection, and, depending on the exact angular position of the object, the drawing is an isometric, dimetric or trimetric projection. Thus, according to the American definitions, orthographic embraces axonometric and "multi-view" projections, and, on this basis, we may say that the Perspector will produce axonometric projections from multi-view projections.

A few simple accessories are provided which are aids to rapid work. For tracing circles less than 1¼ in. in. diameter, with the stylus, thus projecting ellipses, a piece of Perspex with a series of concentric grooves is placed over the circle to be traced and the stylus is traced round the appropriate groove. For larger circles, up to 25 in. in diameter, radius arms are provided; an arm is pinned to the board at the centre of the circle, the stylus is placed in the correct locating hole and then swung round in a circular path. Locating holes are provided at intervals of 0·050 in. An arm with a radial groove is used for tracing lines which radiate from the centre of a circular component. There are also a T-square, French curves, set squares with grooves, a pencil sharpener which ensures concentricity of the point, 2 H-grade pencils, and index strips.

Fig. 4.



(9316.D.) "ENGINEERING"

* *Technical Drawing.* By F. E. Giesecke, A. Mitchell and H. C. Spencer. The Macmillan Company, New York, 1936.

SPEED RECORDER FOR WINDING-ENGINE TESTS.

To comply with the appropriate regulations, all mechanically-driven winders employed in coal mines for winding men in a vertical shaft must be equipped with brakes capable of a specified performance, if the rope speed can exceed 12 ft. per second. They must also be equipped with protective arrangements which will ensure that the landing speed of the descending cage cannot exceed 5 ft. per second when men are being wound. Periodical tests, moreover, must be made to ascertain whether the brakes and protective arrangements meet these requirements. Until recently, the apparatus designed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for making these tests consisted of a tachometer with a hard-rubber disc on its shaft which was connected to a three-ring commutator through worm gearing. The commutator, in turn, was electrically connected to a recorder consisting of an electrically or clockwork driven drum carrying a chart. This chart was traversed at a constant speed in the longitudinal direction by a pen, which was connected to the plunger of a solenoid. The coil of this solenoid was connected in series with a 6-volt battery, or other source of current, and the commutator. When the solenoid was energised by rotating the commutator the pen was moved rapidly in a transverse direction and returned to its original position under the action of a spring when the circuit was broken. Information, such as the point at which the brakes were applied or the time the brake gear was in operation, was recorded on the chart by a second pen, which was also actuated by a solenoid.

A test was made by applying the disc of the tachometer to the winding drum at a radius as nearly as possible equal to that of the rope tread and actuating the charts, solenoids and pens by closing the appropriate switches. The intermittent opening and reclosing of the main solenoid circuit by the rotation of the commutator was then recorded on the chart. These records enabled the average speed of the cage during the whole or part of any wind to be calculated by using a simple formula.

Although it is claimed that with ordinary care this equipment gave accurate results, the necessary computation was tedious. The Company have therefore developed a new type of instrument by means of which the speed/time curve is recorded directly and the interpretation of the results thereby facilitated. This new equipment consists of a transmitter and an indicator, which are mounted on a bracket and can be held in the desired position against the winding drum by two handles. The transmitter, which is provided with a friction disc, is again essentially a tachometer generator, which has been designed to give a linear voltage-speed characteristic down to almost zero speed. The indicator is a voltmeter with a maximum length of scale, which is calibrated in feet per second to show the rope speed. It is provided with a switch, so that its connections can be reversed when the direction of rotation of the winder is changed. The transmitter is connected to a portable recorder, which consists essentially of a centre-zero voltmeter for indicating the speed of the rope in feet per second. This information is also recorded by a pen on a chart carried on a clockwork-driven drum. Two other solenoid-actuated pens enable such information as the time the overwinder trips or the delays that occur in braking to be recorded on the same chart. The recorder case contains a small lamp to assist the operator in poorly-lighted locations and this, like the solenoids, is at present supplied from a 6-volt battery. Models are being manufactured, however, in which a transformer and rectifier will be used for this purpose. Both the indicator and recorder have two ranges from 0 to 15 ft. and from 0 to 60 ft. per second, respectively. These are brought into action by altering the connections on the transmitter. The chart on the recorder is calibrated up to 20 ft. per second, so that when the instrument is operating on the higher speed range its readings must be multiplied by four. The chart runs at a speed of 12 in. per minute, while the maximum movement of the speed-recording pen is 1½ in., which corresponds to a speed of 15 to 60 ft. per second depending on the range that is being used. In carrying out a test, the transmitter is held so that the disc bears against the side of the brake ring or other convenient part of the drum and rotates at a speed proportional to that of the drum. Both indicator and recorder then give the rope speed directly in feet per second, provided the disc is applied to the drum at a radius equal to that of the rope coil. If the radius of application is less than this the readings must be multiplied by the ratio between the radius of the drum measured to the centre of the rope, and the actual radius at which the transmitter is applied.

LAUNCHES AND TRIAL TRIPS.

S.S. "LINCOLN ELLSWORTH."—Single-screw tanker built by Messrs. Blythswood Shipbuilding Company, Limited, Scotstoun, for the A/S. Laboremus (T. Dannevig & Co.), Oslo. Main dimensions: 305 ft. by 44 ft. by 20 ft. 3 in. to upper deck; deadweight capacity, 3,500 tons. Triple-expansion engine, supplied by Messrs. David Rowan and Company, Limited, Glasgow, with two oil-burning Scotch boilers. Launch, May 11.

R.M.S. "MAGDALENA."—Twin-screw passenger and cargo liner built by Messrs. Harland and Wolff, Limited, Belfast, for the South American service of the Royal Mail Lines Limited, London. Main dimensions: 570 ft. by 73 ft. by 45 ft.; gross tonnage, about 17,000. Two-shaft arrangement of Parsons double-reduction turbines, developing a total of 18,000 shaft horse-power. Launch, May 11.

M.S. "LABIOSA."—Single-screw tanker for petroleum and bitumen, built and engined by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, for the Anglo-Saxon Petroleum Company, Limited, London. Main dimensions: 446 ft. by 54 ft. 3 in. by 31 ft. to upper deck; deadweight capacity, about 9,000 tons. Hawthorn-Werkspoor six-cylinder four-cycle heavy-oil engine, developing 2,700 brake horse-power, with a speed of 12 knots fully loaded. Trial trip, May 12 and 13.

M.S. "BRITTANY COAST."—Single-screw coaster for coal and general cargoes, built by The Burntisland Shipbuilding Company, Limited, Burntisland, Fife, for the British Channel Islands Shipping Company, Limited, London. Main dimensions: 170 ft. by 28 ft. by 11 ft. 11 in.; deadweight capacity, about 670 tons on a draught of 11 ft. 9 in. Five-cylinder British Polar Diesel engine of 800 brake horse-power, constructed by Messrs. British Polar Engines, Limited, Glasgow, and installed by the builders. Launch, May 20.

S.S. "IRISH WILLOW."—Single-screw cargo vessel, with accommodation for 12 passengers, built by Messrs. Wm. Gray and Co., Ltd., West Hartlepool, for the Baltic and Mediterranean services of Messrs. Irish Shipping Ltd., Dublin. Main dimensions: 280 ft. by 44 ft. by 25 ft. 6 in. to shelter deck; deadweight capacity, about 2,050 tons on a draught of 19 ft. Triple-expansion engines, producing a service speed of 12 knots, constructed by the Central Marine Engine Works of the builders. Launch, May 22.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Methods for Analysis of Steel.—Parts 2, 3, 4 and 5 of B.S. No. 1121, which deals with methods for the analysis of steel, have now been published. Part 2 covers the determination of nickel in permanent-magnet alloys. Part 3 is concerned with the determination of tungsten in steels not containing columbium (niobium) and tantalum and Parts 4 and 5 deal respectively with the determination of aluminium and copper in permanent-magnet alloys. In all cases the solutions required, the testing procedures and the method of calculation are given in detail. [Price of each part 1*s.*, postage included.]

Structural Use of Reinforced Concrete.—The Codes of Practice Committee for Civil Engineering, Public Works and Building, formed under the ægis of the Ministry of Works, have now issued, in final form, the Code, C.P. 114 (1948), covering "The Structural Use of Normal Reinforced Concrete in Buildings." The publication, which has been prepared by a committee convened by the Institution of Structural Engineers on behalf of the Codes of Practice Committee, deals generally with the type of reinforced-concrete design normally used in the columns, walls, beams, floors and flat roofs of ordinary buildings, but does not cover any constructions of specialised character such, for instance, as those of prestressed concrete. In the section on materials, tables give the minimum compression-strength requirements for the different types of concrete dealt with in the design section. Other tables give the permissible compression or bond stresses which may be assumed in design. Recommendations, supplemented by tables and formulæ, are given for determining bending moments and resistance to shear associated with the design of different types of beams and slabs. The maximum permissible loading of different types of columns is also considered and the Code includes recommendations for solid-reinforcement flat-slab constructions and the columns supporting them. Besides considerations of design, the Code touches on workmanship and particularly on formwork erection, the placing of reinforcement, the mixing, laying and curing of concrete, and the striking and stripping of formwork. [Price 5*s.*, postage included.]

BOOKS RECEIVED.

Quality Control in Production. A Machine-Shop Manual on the Statistical Method of Controlling Product Quality During Manufacture. By H. RISSIK. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 21*s.* net.]

Practical Five-Figure Mathematical Tables. By C. ATTWOOD. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 3*s.* net.]

Annual Report of the Governor of the Panama Canal for the Fiscal Year Ended June 30, 1947. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

United States National Bureau of Standards. Circular No. C466. *American Standard Specification for Dry Cells and Batteries (Leclanché Type).* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 10 cents.]

The Institution of Municipal Engineers. Report on Mining Subsidence. Offices of the Institution, 84, Eccleston-square, London, S.W.1. [Price 5*s.*]

Ministry of Fuel and Power. Fuel and the Future. The Proceedings of a Conference Held in London on October 8, 9 and 10, 1946, Under the Auspices of the Fuel Efficiency Committee. Volume I. [Price 6*s.* net.] Volume II. [Price 6*s.* net.] Volume III. [Price 3*s.* 6*d.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Blackpool Tower. Edited and published by L. ASHLYONS, Yard 119, Highgate, Kendal, Westmorland. [Price 2*s.*]

Standard Valves. Standard Telephones and Cables Limited, Connaught House, 63, Aldwych, London, W.C.2. [Price 15*s.* 6*d.*, post free.]

Into the Atomic Age. By CHAPMAN PINCHER. Hutchinson and Company (Publishers), Limited, 47, Princes-gate, South Kensington, London, S.W.7. [Price 9*s.* 6*d.* net.]

Everyman's Mathematics. By F. G. BROWN. Angus and Robertson, Limited, 48, Bloomsbury-street, London, W.C.1. [Price 36*s.*]

Model Railways for the Beginner. Part I. *Suggestions for the Improvement of Your Tinplate Railway.* Part II. *Building Scale Accessories for Your Tinplate Line.* By ERNEST F. CARTER. Percival Marshall and Company, Limited, 23, Great Queen-street, Kingsway, London, W.C.2. [Price 3*s.* net each part.]

PERSONAL.

CAPTAIN J. N. STEPHENS, M.I.E.E., assistant to the chairman of Associated Electrical Industries Limited, Crown House, Aldwych, London, W.C.2, has now retired. He has spent all his working life in the electrical industry and has taken part in many of the developments which have taken place within it since 1895.

MR. S. V. HICKS was installed as President of the Royal Institution of Chartered Surveyers, 12, Great George-street, London, S.W.1, on May 31, in succession to MR. R. W. TRUMPER.

MR. H. A. LONGDEN, B.Sc. (B'ham), A.M.I.C.E., F.G.S., general manager, No. 8 (Castleford) area, North-Eastern Division (Yorkshire), National Coal Board, has been appointed production director of the Division, as from July 1, in succession to MR. J. HUNTER who is relinquishing the position.

MR. J. W. ANGLES, M.Sc., M.I.Mech.E., Principal of the Technical College, Darlington, is retiring in September.

MR. J. P. CRANMER, M.I.E.E., has been transferred from the Willesden Works of the British Thomson-Houston Company, Limited, to the Birmingham district office, and has been appointed engineer (Midlands area) for the firm.

DR. NORMAN SWINDELLS, M.A., has been appointed chief metallurgist to Messrs. McKechnie Brothers, Limited, Rotton Park-street, Birmingham, 16.

MR. J. R. RYLANDS, M.Sc., M.I.Mech.E., M.I.E.E., chief engineer, Messrs. E. Green and Son, Limited, Economiser Works, Wakefield, has been elected a director of the company.

DR. S. C. REDSHAW, M.Sc., M.I.C.E., F.R.Ae.S., the chief engineer, and MR. G. C. HAYNES, the secretary, of Messrs. Boulton Paul Aircraft, Limited, have been elected directors of the company.

MR. J. W. RUTTY, manager of the Australian branches of Messrs. W. T. Henley's Telegraph Works Company, Limited, retired on May 31. MR. H. W. HAMMOND, formerly manager of the company's Melbourne branch, has been appointed manager for Australia, as from June 1. The firm's head office in Australia is now at the Melbourne branch instead of at Sydney, as hitherto.

DR. I. G. SLATER, formerly scientific adviser, British Admiralty Delegation, Washington, U.S.A., is returning to this country to take up the position of Director of Operational Research, Admiralty, London.

MR. S. D. CANVIN, B.Sc. (Eng.) (Lond.), M.I.C.E., M.I.W.E., general manager, Glasgow Corporation Water Department, has been elected a vice-president of the Glasgow and District Association of the Institution of Civil Engineers and a member of the Council of the Scottish Section of the Institution of Water Engineers.

MR. H. F. PADBURY has succeeded MR. E. HEMINGWAY JONES as chairman of the Ebbw Vale Metallurgical Society and as an honorary member of the Council of the Iron and Steel Institute.

MR. GEORGE ASHTON, A.M.I.C.E., A.M.I.W.E., has relinquished the position of Borough Surveyor of Darwen, Lancashire, to take up a similar post at Nuneaton, on the retirement of MR. R. C. MOON, A.M.I.C.E., A.M.I.W.E.

MR. J. NUTTING, B.Sc. (Leeds) has been awarded the Ph.D. degree of the University of Leeds for a thesis on the overheating and burning of steel. He has now taken up an appointment with the British Iron and Steel Research Association.

An announcement made by the Merseyside and North Wales Electricity Board, Electricity House, Love-lane, Pall Mall, Liverpool, 3, states that the board's chief engineer is MR. P. D'E. STOWELL, B.Sc. (Eng.), A.M.I.E.E., and the sub-area liaison officer, MR. T. COATES, M.Eng., M.I.E.E., M.I.Mech.E. The manager of No. 1 sub-area (24, Hatton-garden, Liverpool, 3) is MR. P. BREGAZZI, M.I.E.E., A.M.I.Mech.E., and the engineer, MR. E. L. MORLAND, M.I.E.E. The manager of No. 2 sub-area, (Sandiway House, near Northwich) is MR. N. T. SMITH, M.I.E.E., A.M.I.Mech.E., and the engineer, MR. B. DIXON, M.I.E.E. Mr. T. Coates, the sub-area liaison officer, is acting temporarily as manager of No. 3 sub-area (Electricity House, Newgate-street, Chester), while MR. T. V. LIRONI, M.I.E.E., is the engineer. The manager of No. 4 sub-area (Electricity House, Rhostyllen, Wrexham) is MR. C. BOLLAM, A.M.I.E.E., and the engineer MR. A. M. MANSFIELD, M.I.E.E.

MR. A. F. ANDREWS, schedules superintendent (road transport), London Transport Executive, 55, Broadway, London, S.W.1, retired on May 29, after 42 years' service. His successor is MR. C. J. MAYS.

MR. J. E. FARRELL, M.B.E., has been elected President of the Institution of Fire Engineers for the session 1948-1949 in succession to MR. E. MCKINNELL, O.B.E.

The Manchester branch office of the BRITISH ALUMINIUM COMPANY LIMITED, has been removed from Chancery Chambers, 55, Brown-street, to 46, Fountain-street, Manchester, 2. The telephone number remains the same, namely: Deansgate 3639.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Production is being maintained at near record levels, but makers are not happy about the general position, as practically no progress is being made with the laying down of scrap reserves to ensure that the present rate of production can be continued. All practical steps have been taken to guarantee that the steel-making plant will be capable of meeting target requirements; a reasonable share of available coke supplies has been assured for the blast-furnaces, and limestone and other raw materials are fairly certain to be adequate, but scrap deliveries are only on a day-to-day basis and there seems little possibility of increasing supplies for the winter period. Scottish makers are at present producing about 15 per cent. of the total steel output of the United Kingdom, while pig-iron is running at about 13,700 tons weekly, or some 8 per cent. of the total. Shipments of Scottish steel products have been quite important recently, and included substantial tonnages for Finland and Egypt.

Scottish Coal.—One day last week three collieries in Lanarkshire and Ayrshire were completely idle for various reasons. At Auchincruive No. 4 and 5 pits, a dispute over working conditions led to an unofficial strike, and 12 men originally concerned were served with summonses by the N.C.B. for alleged breach of contract. A partial stoppage at Priory Colliery was firmly handled by the N.C.B., who, however, instead of carrying out their threat of last March to close down the pit if production were again interrupted by an unofficial stoppage, dismissed the offending oncost strikers, whereupon normal working was resumed. Deep-mine outputs during Whitsun week amounted to 472,300 tons, compared with 473,500 tons in the previous week. During the 16 weeks to April 24, Scottish production was 7,637,000 tons, compared with 7,497,000 tons in the corresponding period last year. Divisional engineers are planning to reallocate manpower in order to increase the output per man-shift within the next three years from 1·13 tons to 1·35 tons. Opencast production in Fife and the Lothians has expanded considerably of late, where the quality is better than at some of the other sites. The domestic demand for fuel is declining, but industrial and steam coals are being fully taken up. The production of anthracite is being steadily maintained, but the surplus of large sorts is still small.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Prospects of an early development of the Spanish trade which has been in abeyance, except for a recent single cargo, since early in the war, seemed bright on the Welsh steam-coal market last week. Before 1939 Spain took very substantial quantities of Welsh coals and in 1938, although trade had then not recovered from the setback caused by the Spanish civil war, took more than half-a-million tons. The recent cargo was in respect of opencast smalls, but it was obvious that Spanish buyers were not interested in these qualities. Following the proposed trade-agreement talks, in which provision is made for coal deliveries, two cargoes of better quality coals have been allocated during the past week. They were each in respect of about 3,000 tons for delivery to Barcelona. A cargo of about 3,000 tons of locomotive coals was arranged for delivery to Norway, while the second cargo of patent fuel to be arranged recently has been booked for Rio de Janeiro. Up till May 16 this year the South Wales ports have shipped 2,200,737 tons of coal and coke, as against 1,746,341 tons in the same period of last year. This includes all coal handled, both cargo and bunkers, sent coastwise as well as to foreign destinations. Patent fuel shipments have risen sharply from 61,437 tons in 1947 to 113,385 tons. There has been a brisk demand for all grades on the steam-coal market during the past week, but the shortage of supplies has kept trading within close limits. The needs of the principal home consumers are still heavy and are providing an outlet for almost the whole of the productions of better sorts. Cokes are in keen request but are not easy to secure, while patent fuel is well booked ahead.

Swansea Steel Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was less active in regard to new orders, not owing to any weakness in the demand but because most, if not all, the makers are very heavily committed for the remainder of the current quarter. The export market was also quieter and the sales were further reduced. Steel sheets continue to have a strong demand and, as makers are inundated with priority orders, new business is difficult to negotiate. Iron and steel scrap is in very strong demand and all steel works are anxious to receive much larger quantities. Last week, coke tin-plates were 37*s.* 0½*d.* per standard box of 108 lbs., containing 112 sheets: unassorted tin-plate base uncoated plates, 29*s.* 7½*d.*; and unassorted terne-plates, 69*s.* 2*d.* per box.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Modernisation of the equipment and lay-out of iron and steel foundries and steelworks is being continued and additional high-frequency electric furnaces are being installed to increase the supply of high-grade steel which is in great demand. Additional heat-treatment furnaces also are being installed at some leading works. The demand for steel and steel products is heavy and production is as high as the shortages of materials and the operation of restrictions will permit. Some firms are unable to satisfy the requirements of old customers abroad because of materials shortages. In an effort to attract labour, the Brightside Foundry and Engineering Company have completed the installation of baths for foundry workers and two lockers for each worker so that a change into clean clothes is possible after a bath is taken. Newton, Chambers and Company have secured a contract for the supply and installation of a new gas-holder for the township of Scunthorpe at a cost of 60,000*l.* Work is proceeding steadily on the production of large hollow forgings in the form of steel drums for electric power stations in this country and Australia. There is a strong demand for high-grade steel strip the production of which is to be increased.

South Yorkshire Coal.—Increasing absenteeism in the South Yorkshire coalfield is causing anxiety, and it is stated that loss of working time is greater than in any other coalfield of the country. Supplies of coal are still rather short. The official holiday of one day at Whitsuntide was followed by pronounced absenteeism entailing a loss of two days' production. Strong demands are being made for export. From Yorkshire pits an average of between 40,000 and 50,000 tons of coal a week is being sent abroad, most of it best-quality steams with some gas coal. Locomotive hards are in strong request and the heavy demand for coking coal continues.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The total production of iron and steel on Teesside is heavy and increasing, but is still much below customers' urgent requirements. Bigger deliveries of fuel would be welcome and supplies of limestone are not very plentiful, while the yield of the Cleveland ironstone mines is still insufficient for the users' current needs. Any appreciable expansion in supplies of these commodities would doubtless be followed by an increase in pig-iron production and in the make of other commodities wanted in large quantities for home purposes and for the export market. Imports of high-grade foreign iron ore are maintained at a high level and are moving promptly into use owing to the inadequate supplies of native ironstone, and to the fact that they can be smelted with a low consumption of coal, which is a major consideration both in this country and on the Continent.

Foundry and Basic Iron.—Foundry pig-iron consumers have to draw nearly all their supplies from distant producing areas and there is no likelihood of a resumption in the make of Teesside brands, the output of which ceased some time ago, while the occasional production of a substitute quality of iron is extremely small. This, together with the shortage of cast-iron scrap, continues seriously to hamper operations at foundries turning out commodities needed in large quantities. Basic-iron makers are providing their own consuming plants with only sufficient tonnage for their present essential needs.

Hematite, Low-Phosphorus and Refined Iron.—The limited production of East-Coast hematite is readily taken up by regular customers, all of whom are pressing for increased deliveries on a scale that would permit some re-building of stocks. Manufacturers of low- and medium-phosphorus grades of iron are distributing tonnage at a rate that deals satisfactorily with the demand. Outputs of refined iron are in steady request.

Manufactured Iron and Steel.—Semi-finished and finished iron manufacturers are actively employed and are booking orders for delivery after the end of June, while steel producers have plants running to the limit of capacity in an endeavour to keep abreast of their heavy commitments. Steel semies are still wanted in larger parcels than are coming forward; very little Continental material is obtainable, but home makers are supplying re-rollers with better lots than of late. Finished descriptions of steel are taken up as soon as they become available. Production is well maintained and there is no sign of any reduction in either home or overseas demand. More tonnage, in fact, is being shipped abroad under the new trade agreement. At the same time makers are supplying home customers with large quantities of material and are rapidly filling up their order books for delivery over the third quarter of the year. Buyers are pressing for maximum supplies of sheets, plates, angles, railway requisites and colliery equipment.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section:* Tuesday, June 8, 7.15 p.m., Technical College, Walsall. Film: "Wheels Behind the Wheels."

INSTITUTE OF PETROLEUM.—Wednesday, June 9, 26, Portland-place, W.1. 4 p.m., (i) "Fundamental Work on Combustion in Germany," by Messrs. D. S. Petty, E. P. Wright and H. L. West. (ii) "Compression Ignition Applied to the Otto Cycle: The 'Ring' Process," by Mr. M. O'Farrell. 5.30 p.m., Adjourned 34th Annual General Meeting (for members only). 5.45 p.m., (iii) "Fundamental Work on Friction, Lubrication and Wear in Germany," by Mr. E. D. Tingle. (iv) "Major Developments in Synthetic Lubricants and Additives in Germany," by Mr. H. L. West.

INCORPORATED PLANT ENGINEERS.—*Newcastle-upon-Tyne Branch:* Thursday, June 10, 7.30 p.m., Y.M.C.A., Connaught Rooms, Newcastle-upon-Tyne. Discussion on "Roller Bearings." *Western Centre:* Wednesday, June 16, 7.15 p.m., Grand Hotel, Bristol. "Factory Building," by Mr. E. O. James. *Liverpool Branch:* Thursday, June 17, 7.30 p.m., 9, The Temple, 24, Dale-street, Liverpool. Joint Meeting with the Liverpool Engineering Society. "The Elimination of Vibration," by Mr. R. B. Grey.

INSTITUTION OF MECHANICAL ENGINEERS.—Tuesday, June 15, to Thursday, June 17, Royal Technical College, Glasgow, Summer Meeting. Tuesday, June 15, 10 a.m., Civic Welcome. 10.30 a.m., "Some Recent Advances in Mechanical Engineering on Shipboard," by Mr. T. A. Crowe. Afternoon, various alternative visits to works. 8 p.m., Civic Reception in the City Chambers. Wednesday, June 16, 10.30 a.m., Automobile Division paper on "Export Vehicle Design," by Mr. H. W. Fulton, followed by an afternoon works visit; or, various alternative whole-day fixtures. 7.45 p.m., Institution Dinner in the Grosvenor Restaurant, Gordon-street, Glasgow. Thursday, June 17, various alternative whole-day fixtures. 8 p.m., Conversazione, arranged by the Scottish Branch, at the Royal Technical College.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 16, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "The Operation of Ocean Weather Ships," by Captain C. E. N. Frankcom. (ii) Discussion on "Optical Properties of the Atmosphere," to be opened by Mr. James Paton.

INSTITUTION OF MINING AND METALLURGY.—Thursday, June 17, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Impressions of Mining Practice in North America," by Mr. J. Spalding.

EXHIBITION OF INVENTIONS, BIRMINGHAM.—The second annual exhibition organised by the Birmingham branch of the Society of Inventors will be held in the Chamber of Commerce Building, Birmingham, from October 25 to 30. Entries are accepted from non-members as well as from members of the Society and anyone wishing to enter an exhibit, which must have been patented, protected or of registered design, should communicate with the honorary branch secretary, Mr. B. Thornton Clark, 244, Stoney-lane, Yardley, Birmingham, 25.

FOREIGN MEMBERS OF THE ROYAL SOCIETY.—At a meeting of the Royal Society, held on May 27, four distinguished scientists were elected Foreign Members of the Society. They were Dr. D. W. Bronk, of Philadelphia, Foreign Secretary of the National Academy of Sciences of the United States and chairman of the National Research Council; Professor L. E. J. Brouwer, who occupies the Chair of Mathematics in the University of Amsterdam; Professor M. J. G. C. Caullery, of the Faculty of Biological Science, University of Paris; and Professor L. C. Pauling, who occupies the Chair of Chemistry at the California Institute of Technology, Pasadena, United States.

SUMMER SCHOOL IN ELECTRICAL ENGINEERING.—The detailed syllabus of a summer school in electrical engineering, organised by the education department of the British Thomson-Houston Company, Limited, Rugby, has just reached us. The school proceedings will open with a dinner at 7.30 p.m., on Monday, July 12, at the Grand Hotel, Rugby, and will close after luncheon on Friday, July 16. The object of the school is to enable academic persons holding professorial and other posts in electrical engineering to obtain a knowledge of the more important recent advances which have taken place in the industry. Numerous lectures and addresses will be given by various authorities and these will be interspersed with visits to works.

SOME LESSER-KNOWN TRACTION ENGINES.

(*For Description, see Page* 529.)

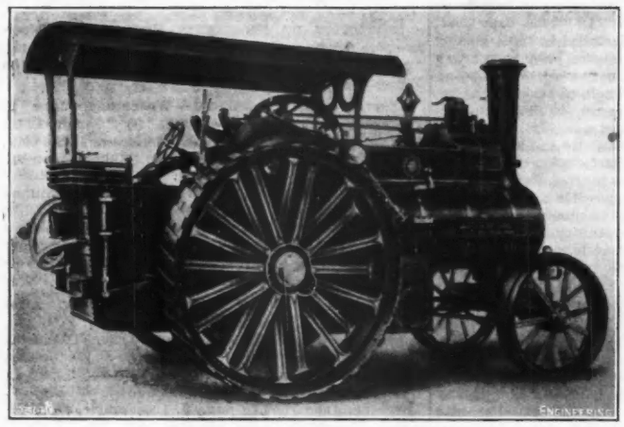


FIG. 13. FODEN 10-N.H.P. ROAD LOCOMOTIVE.

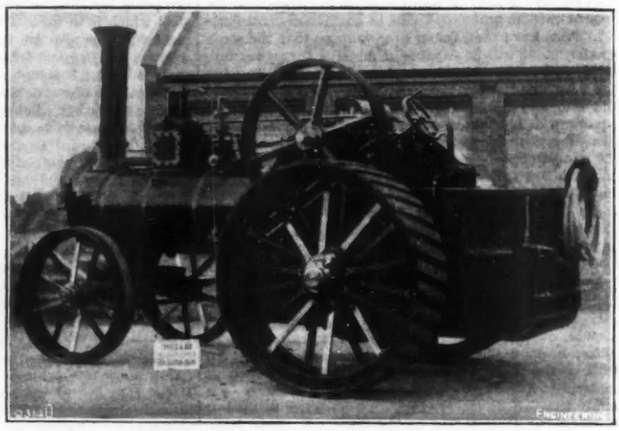


FIG. 14. FOWELL SHOW ENGINE, EXHIBITED IN 1914.

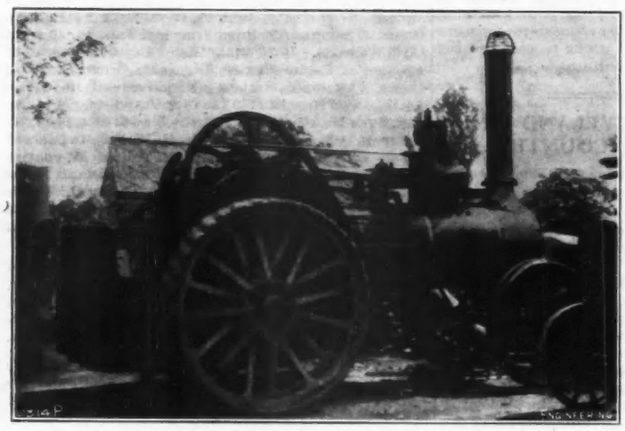


FIG. 15. FYSON GENERAL-PURPOSE ENGINE.

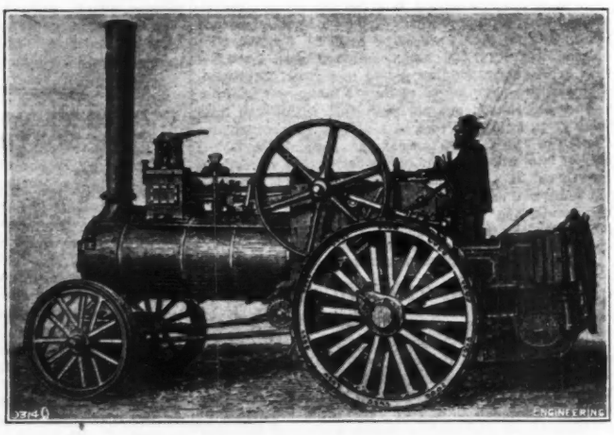


FIG. 16. FOUR-SHAFT TRACTION ENGINE BY HOLMES, OF NORWICH.

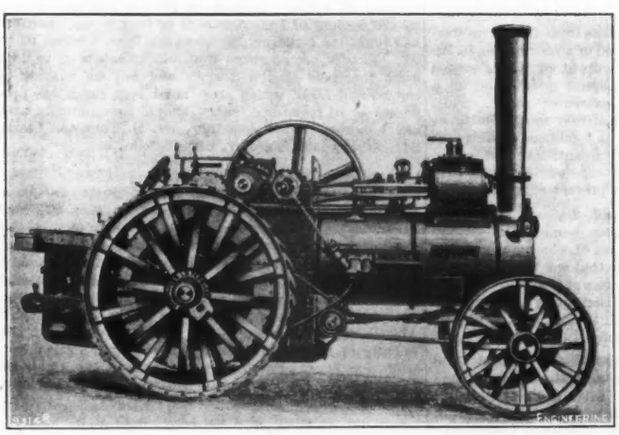


FIG. 17. GENERAL-PURPOSE ENGINE BY E. HUMPHRIES, OF PERSHORE.

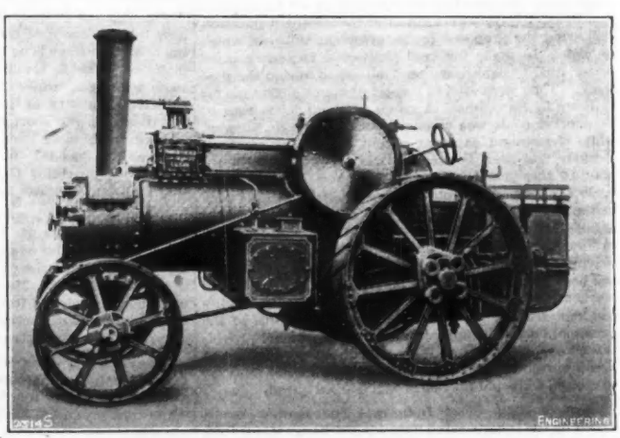


FIG. 18. MANN'S 5-TON LIGHT TRACTION ENGINE.

COAL EXPORTS FROM GREAT BRITAIN.—Statistics issued by the Economic Commission for Europe show that in March, Great Britain was the fourth largest supplier of coal to European countries. Her total was 363,000 tons. The first three suppliers were: the United States, with 2,201,000 tons; Western Germany, with 1,399,000 tons; and Poland, with 913,000 tons.

BRITISH RAILWAYS TRACK RENEWALS.—The Railway Executive confidently anticipate that 1,226 miles of track will be completely renewed, and 550 miles partly renewed, on British Railways during the current year. They had hoped to overtake some of the war-time arrears of re-newals, but the present economic position does not permit this. Nevertheless, some temporary speed restrictions will be removed.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.—Two conferences, each to be held in the autumn at Ashorne Hill, near Leamington, are being arranged by the British Iron and Steel Research Association, 11, Park Lane, London, W.1. The first conference has the support of the Institute of Physics and is to discuss the non-destructive testing of castings. It will be held on September 8 and 9. The second conference is planned for October 21 and 22 and is to discuss foundry core bonding agents. Three sessions will be held at each conference. Further particulars regarding the two meetings may be obtained on application to the Association at the address given above.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

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For Canada	£4 5 0

Subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, mentioning the agent's name and address.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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ENGINEERING

FRIDAY, JUNE 4, 1948.

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COLLEGE GRADUATES IN INDUSTRY.

IT has been stated that the Universities of Oxford and Cambridge will be able to admit only about one in twelve of the student applicants for the next academic year, beginning in the autumn. No doubt, similar conditions exist in connection with London and the provincial universities, but, even if this figure is approximately correct, it does not follow that only one in twelve of those who desire to enter a university will succeed, since, in view of present conditions, many will put their names down for more than one college or university. The shortage of accommodation for entrants from school, which has existed since the end of the war, has been due to the entirely proper policy of giving preference to ex-Service men, but this procedure has naturally reacted harshly on members of the younger generation who were fortunate, or unfortunate, enough to be too young to be called up for a number of years' service in the armed Forces. The waiting list of ex-Service men who have a claim for preference is not yet exhausted and the majority of those who have obtained admission have not yet completed their courses. Whether the proportion of acceptances for next year be one in twelve or some more satisfactory figure, the youth whose scholastic career and educational aims have been directed towards a university course may be disappointed. The Barlow Report of 1946 recommended that arrangements should be made for doubling the output of graduates from British universities, but the implication of such a policy, involving much building work and the collection and training of greatly increased teaching staffs, is likely to prove such a long-term policy that it is of little interest to the youth who is fully qualified to enter on a university course but is unable to obtain an entry anywhere.

The Barlow report was not specifically concerned with the present emergency, which is essentially due to the fact that some five years' production of graduates was lost during the war and an attempt has to be made to make up leeway at a time when physical capacity has been reduced; owing to war damage, University College, London, in October, 1946, was, able to accommodate only 20 per cent. of the students who applied. The main thesis of the report was that the economic and social well-being of the country required that a greatly-increased proportion of its inhabitants should have attained an education of university standard. It is clear from the extent of student applications that the human material necessary to build up that increased proportion is available, and it is a fair assumption that the majority of those concerned are of sufficient natural ability to justify their claim to a higher education.

In the main, the Barlow Report laid stress on the necessity for greatly increasing the number of science graduates and, while that necessity need not be questioned, many bodies which have reported on some aspect of higher education have emphasised that a narrow scientific or technological training is undesirable and that specialist education should be meliorated by admixture with broader and more general interests. Even the Scientific Man-Power Committee attached "very great importance to the atmosphere of an association of men and women which takes all knowledge as its province, and in which all branches of learning flourish in harmony." This is, roughly, a definition of a university, as opposed to a technical college and, without any reflection on the excellent work done by the latter type of establishment in its own sphere, it will be generally admitted that the student obtains much benefit from the wide and varied contacts and friendships he makes at a university, especially if it be of the residential type. In spite of this general admission, there is some tendency to introduce highly specialised courses, and to create specialised chairs, such as one dealing with concrete technology, even in universities. In the sphere of engineering, there has been much discussion in the past about the extent to which the teaching of specific technological subjects should be grafted on to broad training in principles. Some specialisation is necessary towards the end of a course and a third-year electrical-engineering student will not be doing the same work as one reading to become a mechanical engineer; that is not to say, however, that the former student should narrowly confine his interests to such a subject as electronics.

This raises the question of the aim of a college education. Many engineering students may feel a special interest in some particular branch of the wide profession they are to enter, but in most cases they will not be able to control their own destiny. Many eminent engineers will be found, on inquiry, to have started their professional life in a branch of work having little connection with that in which they have established their reputation. As this article has been inspired by a recent book* by Dr. Percy Dunsheath, it will not be felt to be too personal a remark to point out that he started his distinguished career in the electrical field as an apprentice with Davy Brothers, of Sheffield. The question of the extent to which specialisation should enter into a university education is not Dr. Dunsheath's subject; he is concerned with the varied openings which industry offers to the college graduate, but a young man reading his book might well think that too close a specialisation might close to him many of the types of industrial career which are dealt with.

There is a tradition that the more attractive and promising appointments in the administrative branches of the Civil Service are given to men with degrees in classics or history, and it is probable that many Arts men still read with some branch of that service in view. The argument in favour of this practice is that in, say, the Foreign Office, a broad general education of high standard is of more value than specialised attainments, except, possibly, for this service, knowledge of foreign languages. Civil Service appointments, however, now include many of a scientific and technical nature which will not be awarded to men who have not got the necessary specialised training, and some branch of the Civil Service is now probably the aim of many students of engineering and other scientific subjects. Many men are attracted to the Civil Service because it is safe and does not involve the hazards inseparable from private industry, but fortunately that service cannot absorb anything like the total number of science graduates which is being produced and,

* *The Graduate in Industry.* By Dr. Percy Dunsheath, C.B.E., M.A., Hutchinson's Scientific and Technical Publications, 47, Princes-gate, London, S.W.7. [Price 10*s.* 6*d.* net.]

fortunately also, many men are attracted by the greater freedom and the greater scope for individual initiative which is offered by the wide field of industry. No doubt, a very considerable proportion of the total number of students have no fixed ideas about what type of activity they wish to engage in, and it is clear, merely on a numerical basis, that, in any case, a high proportion of them will necessarily enter industry.

It is the purpose of Dr. Dunsheath's book to indicate the very wide field of employment which modern industry offers and, incidentally, to show that the science student will increase the number of possible avenues for his future advancement by taking full advantage of the possibilities which a university training offers for broadening his general outlook and educational experience. In order to establish a background against which a student or a graduate may evaluate the various activities which are described, a general account of the structure of industry and of the organisation of research is given. This latter aspect of industrial activity attracts many science graduates, but it would be undesirable that industrial research laboratories and departments should become too exclusively staffed with the academic type of man. Fortunately, the graduate-apprentice courses now operated by many large engineering firms provide for passage through the commercial shops for all comers, including those who ultimately pass to research departments.

The part which engineers play in the spheres of design and production in manufacturing industry need not be dealt with here, but reference may be made to the considerable attention paid by Dr. Dunsheath to the question of engineers as administrators. He states that, despite some signs of a better appreciation of the true position, "even now it seems to be assumed in some parts of the Civil Service that the man with knowledge of the work should be directed and controlled by one who has no such equipment." This is a matter which has been the subject of much discussion in the past. At one time, engineers and other scientific men were practically never appointed to important administrative posts, and although such appointments are now relatively common, a notion lingers that the administrator, with supposedly broad views, need not have scientific knowledge of the work carried on in the organisation which he controls. The danger of this idea is that it contains an element of truth. The head of a large research organisation, dealing with numbers of complicated problems, will not have, and will not be expected to have, detailed knowledge equal to that of some of his subordinates, of some of the specific researches carried out. This is not to say, however, that he can do without a sound basic knowledge of the whole of the work of his organisation. The fact that he is a good scientific man will not make him necessarily a good administrator, but however good his administrative ability may be, it cannot be employed effectively in a department engaged in the application of scientific knowledge of which he has no knowledge.

Graduates reading Dr. Dunsheath's book will learn the importance of taking full advantage of the opportunities a university education offers to enlarge their contacts and outlook in view of the possibility that managerial or administrative duties may ultimately be found to be associated with their technical activities. The importance of scientific men obtaining training in what may be called business methods has now so far been recognised that special courses have been arranged at various educational institutions. This book is not confined to the interests of engineering graduates and valuable information is given about possible openings in personnel and educational work in industry. Medical service, accountancy, and "The Padre in Industry," are also dealt with, and there is a useful chapter, applicable in any sphere, about the value of training in logical and clear expression both in writing and speaking. In conclusion, Dr. Dunsheath points out that while much remains to be done to bring to the universities a more sympathetic understanding of industry, industry has a great deal to learn from the universities and interchange of ideas will benefit both.

PRODUCTION PER MAN-HOUR.

WHEN, in March, 1947, the Wolverhampton Section of the Institution of Production Engineers held a one-day conference on "National Productive Efficiency"—as reported on page 193 of our 163rd volume—one of the speakers made the somewhat provocative assertion that, if the average British engineering works could be transported bodily to Canada and staffed with Canadian personnel, the output would be 50 per cent. greater than in Britain; and, if it were similarly transplanted to the United States, without change of equipment, and manned with United States labour, the output would be doubled. It may be that some memory of this comparison inspired the selection of the general subject of "Production per Man-hour" for this year's conference of the Wolverhampton Section, which was held in the Wolverhampton and Staffordshire Technical College on Saturday, May 22; but, whether this suggestion is in accordance with the facts or not, there can be no question that the subject is one of crucial importance at the present time, ranking in that respect second only to the primary and general problem, affecting so many engineering establishments to-day, of obtaining sufficient raw materials with dependable regularity and of assured and consistent quality.

The programme opened with a civic welcome by the Mayor of Wolverhampton (Alderman H. E. Lane, J.P.) and an address by Major J. Freeman, M.P., Joint Parliamentary Secretary to the Minister of Supply, on "The Importance of 'Production per Man-hour' to the Nation," after which four papers were presented. The first of these was by M. Robert Caussin, Administrateur-Directeur of the Belgian National Committee for Scientific Organisation, on "Belgium's Contribution to 'Production per Man-hour'"; and the second, by Miss A. G. Shaw, M.A., President of the Motion-Study Society of Great Britain, was entitled "Motion Study and Elimination of Waste Time." It dealt with the application of motion study to machining, assembly, and handling of materials, showing how waste time could be eliminated and the effort transferred to extra production. The afternoon session opened with an address on "America's Contribution to 'Production per Man-hour'" by Mr. James Y. Scott, President of the Van Norman Company, Massachusetts; and the final paper was that of Mr. B. H. Dyson, on "The Practical Side of 'Production per Man-hour' in Production Shops." At the end of each session, there was a discussion on the papers delivered in that session, and, at the close of the Conference, a general summing-up was undertaken by Mr. Norman Rowbotham, C.B.E., President of the Institution of Production Engineers.

It is not practicable to attempt a summary of all the addresses—some of which, indeed, could do little but cover ground that was already well known to a considerable proportion of the audience; the principal value of most of the papers, in fact, lay in the occasional new and striking presentation of some aspect to which long-continued familiarity had bred, if not the proverbial contempt, at least an unintentional and possibly unrealised indifference. The contributory factors which together constitute efficiency are neither new nor unknown; rather are they so old that they have become too well-known, until merely to recapitulate them is liable to produce irritation instead of better production. If, however, they can be shown in some new light, they may be found still to possess the power to arouse interest and a desire for improvement; but it is more than a little doubtful whether such a desire can be instigated by revealing, as though it were a novelty, something that most of the audience have appreciated only too well and have been urging without avail for several years. That, unfortunately, was the position of Major Freeman in proclaiming the gospel of more production and fewer restrictive practices, as now officially sponsored by His Majesty's Government.

Most of what he had to say was true enough, of course; but it was true long before the present Government were prepared to admit its truth, and when some of their most energetic spokesmen were actually opposing the very policies that they now advocate. It would be comforting to believe that this change of front is the result of a genuine change of heart. Perhaps it is, in some cases—if so, all who are directly concerned with the welfare of British industry and trade should be appropriately thankful; but too often any such impression is wiped away, a couple of sentences later, by some jab at employers or managements or the investing public, which suggests that, after all, the change is only in the incidence of expediency. Major Freeman's address was refreshingly free from this kind of pinpricking, but it was not entirely devoid of such ancient generalities as the advantages of standardisation, the benefits to be derived from progress planning, and the wisdom of remembering that human beings are not machines.

In his contribution, M. Caussin, said the individual production of the Belgian workman had improved continuously as a result of the full use of the capacity of factories and machines, the application of the optimum intensity of work, and the complete use of the time available for work. His paper, though sound enough so far as it went suffered similarly from somewhat protracted revelations of the obvious and hardly provided a full explanation of the seemingly greater productivity of Belgian labour, as compared with conditions in this country, in almost every branch of industry. In some respects, as M. Caussin pointed out in an itemised comparison of the immediate post-war situation in Belgium with that of other European allied countries and especially of Britain, Belgium was singularly fortunate; but he did not wholly explain why it is that, while the Belgian workman presumably works because he must, under the influence of economic circumstances, just as does his opposite number elsewhere, he also appears to work as though he likes work for its own sake, which is not so commonly obvious among his neighbours. This difference, it seems to us, was not so marked before the war; but whether (if this is so) it is because the Belgian of to-day really works harder than before the war, or because his fellows under other flags work less hard is not easy to assess with accuracy. Variations in relative standards of nutrition may well play a bigger part than the Ministry of Food are prepared to admit—bearing in mind, in attempting any such comparison, that effective nutrition involves, to some extent, psychology as well as mere calories.

On the practical side, the paper by Mr. B. H. Dyson was perhaps as valuable as any, if only for the reason that his rather numerous rhetorical questions were backed in many instances by factual experience. What he had to say, however, really boiled down to the old problems of providing adequate incentives, of establishing and maintaining efficiency in management, and of avoiding waste in all its forms—waste of time, waste of material, and waste of effort. M. Caussin, arguing along similar lines, attempted to determine productive efficiency in terms of percentages, without being entirely convincing as regards the actual figures, which must necessarily vary within fairly wide limits from trade to trade, shop to shop, and between man and man or machine and machine. Mr. Dyson was content to take a broader view—too broad for detailed discussion in a limited space; but his analysis of incentives deserves to be quoted, and might be studied with advantage on a Governmental level. He expressed the opinion that all incentives could be grouped under the three main headings of "Must," "Should," and "Desire." The "Must" category—the motive of fear—he regarded as being outmoded and unable to produce sustained effort; the "Should" incentive—"we should work harder"—as being too idealistic and remote to mean anything to the ordinary individual; but the "Desire" class, the motive of personal enthusiasm, he considered to be possibly the only real incentive of them all, and one capable of practically universal application. He might have added, however, that its universal applicability necessarily involves a degree of personal freedom in the selection and enjoyment of the reward that may be difficult to reconcile with the extent of interference that appears to be inseparable from what is understood to-day by a "planned economy." Enthusiasm cannot be produced to order.

NOTES.

AIR COMMODORE WHITTLE.

AT the end of last week the news was published that the Treasury and the Ministry of Supply had received a recommendation from the Royal Commission on Awards to Inventors that a total award of 100,000*l.*, free of tax, be made to Air Commodore Frank Whittle, C.B., C.B.E., M.A., M.I.Mech.E., F.R.Ae.S., F.R.S., in respect of his achievements in the science of aeronautics by devising and developing practical means of applying the principle of jet propulsion. Mention was also made of his improvements in the designs of gas turbines and air compressors for use in connection with jet propulsion. The Treasury and the Ministry of Supply accepted the recommendation of the Commission and it is with pleasure that we congratulate Air Commodore Whittle on receiving, at the hands of the Government of his country, this tangible recognition of his efforts and perseverance. Although only 41, on Tuesday, June 1, Air Commodore Whittle has been the recipient of many high honours. In 1944 he was made a C.B.E., and in the same year was awarded the Gold Medal of the Royal Aeronautical Society (awarded only on seven previous occasions) and the James Alfred Ewing Medal of the Institution of Civil Engineers. In 1944 also, he was made an honorary life member of the Institution of Mechanical Engineers, and in the following year, 1945, was awarded the first James Clayton Prize of the Institution and delivered the first James Clayton Lecture on "The Early History of the Whittle Jet-Propulsion Gas Turbine," on October 5. He was created a Companion of the Order of the Bath in 1947 and elected a Fellow of the Royal Society on March 20 of that year.

INTERNATIONAL CONFERENCE OF SHIP-TANK SUPERINTENDENTS.

The announcement is made by the Ship Division of the National Physical Laboratory that the Fifth International Conference of Ship-Tank Superintendents is to be held at the offices of the British Shipbuilding Research Association, 5, Chesterfield-gardens, Curzon-street, London, W.1, from Septemper 14 to 17; these dates have been chosen in relation to the autumn meeting of the Institution of Naval Architects, to be held in London in September, and the Seventh International Congress of Applied Mechanics, also in London, which is arranged for the period September 5 to 11. The four previous Conferences were held before the war, in alternate years, and the initiative of reviving them was taken by Sir Charles Darwin, F.R.S., Director of the National Physical Laboratory. Following discussions with various tank superintendents, who favoured the proposal to meet in London, invitations were sent to a number of institutions in this country and abroad, and an organising committee was formed of representatives drawn from these bodies. The sponsors include the Admiralty Experiment Works, Haslar; the British Shipbuilding Research Association; the National Physical Laboratory; the Royal Aircraft Establishment, Farnborough; and Messrs. John Brown and Company, William Denny and Brothers, Saunders-Roe, Limited, John I. Thornycroft and Company, and Vickers-Armstrongs Limited. The purpose of the conference is the discussion of tank technique and related problems, rather than the presentation of research papers, and the number of subjects to be considered has been purposely limited in order that adequate attention may be given to all of them. The matters to be considered are skin friction, the choice of a suitable Reynolds number for model-screw experiments, the use of turbulence-promoting devices in model experiments, and cavitation-tunnel tests. It is expected that about 40 delegates will attend the conference.

WILBUR WRIGHT MEMORIAL LECTURE.

The thirty-sixth Wilbur Wright Memorial Lecture was delivered by Mr. Arthur Gouge before a meeting of the Royal Aeronautical Society held in London on May 27. The lecture was concerned mainly with the size of transport vehicles and its effect on operational economy. Mr. Gouge introduced his lecture by referring to his belief that, if history could be interpreted correctly, it should be able to help us to avoid the mistakes made by our forefathers. He went on to point out that the frequency of operation for nearly all forms of transport was dependent on, and nearly equal to, the period occupied by the journey, and concluded that if the journey by air occupied, say, one hour, then the frequency of service should be one hour. Mr. Gouge then referred to the Atlantic crossing and said that if speeds of 350 to 400 miles an hour could be assumed, then the elapsed time of the journey would be from nine to ten hours, which, in his opinion, called for a service of from two to three aircraft a day by each operating company. Unless it were limited by other considerations, the size of vehicle was determined by the potential volume of traffic; all forms of transport had grown from small vehicles to the largest possible and invariably the largest units had proved the most efficient. So far as the long-range problem was concerned, Mr. Gouge suggested that, in the interests of safety, the journey should be made from point to point, so as to avoid intermediate landings and take-offs; we must be prepared, therefore, to build much larger aircraft than at present. The size and cost of aerodromes, however, were becoming prohibitive, and he considered it doubtful whether we should proceed much farther in this direction. This meant that, if we are to extend existing services, it was essential to develop our large flying boats as, in his opinion, these were the only aircraft which could be developed in size without high ancillary costs. So far as short-range journeys between large centres of population were concerned, Mr. Gouge considered that the air traffic was likely to be of the order of thousands a day rather than hundreds, and made the important point that the aircraft industry should have no difficulty in providing the necessary designs for that route without having to consider all other routes in the world at the same time.

SUMMER MEETING OF THE WHITWORTH SOCIETY.

After a long interval caused by the disturbance of the war, the Whitworth Society resumed its summer meetings this year, a visit being paid to Bristol on May 25 and 26. The usual dinner was held at the Grand Hotel under the chairmanship of Professor Andrew Robertson, the President. This is by tradition an informal function and serves the excellent purpose of enabling contacts to be made and friendships established or strengthened. Apart from appropriate remarks and greetings by the President, the only contribution in the nature of a speech was, by invitation, made by Mr. Harry Shoosmith, probably the oldest Whitworth scholar, as he obtained his distinction 68 years ago, in 1886. Mr. Shoosmith is believed to be the last of the scholars who underwent the practical workshop test at Sir Joseph Whitworth's factory, which was prescribed in the original regulations. He was not, however, able to record that he talked with the great man. He certainly saw him, as Whitworth passed and looked at him at work but made no comment either commendatory or critical. The second day of the meeting was occupied with a visit to the works of the Bristol Aeroplane Company, where the Society was entertained to luncheon and tea. Time naturally only permitted inspection of a few of the shops of this large organisation, but various machine tools of special interest were brought to the notice of the visitors. These included Archdale spline millers adapted to produce the inlet and outlet pockets of turbine-engine impellers; an Orcutt spline grinder adapted to form the "Fir Tree" root on turbine blades; and a Maag HSS.60 helical- and spur-gear grinder. This is the only machine of this type at present in this country. It incorporates top and root relieving mechanism; the gear is given a reciprocating movement to and from the grinding wheel, to correspond with the relief required, as well as the normal oscillating movement. The experimental test hangars, laboratory, turbine-blade development shop, and other departments, were also visited. The afternoon was devoted to an inspection of the Filton shops and hangars and various types of aeroplane, including the Brabazon I air liner, a Bristol freighter and a Bristol helicopter. The fuselage length of Brabazon I is 177 ft. and the wing span 230 ft., and the erecting hall in which future Brabazons will be built is an imposing structure with an overall width of 1,052 ft. and a centre bay 420 ft. long; the doors are 1,045 ft. long by 65 ft. 9 in. high. The enlarged West Filton runway is 2,750 yards long with a 2 ft. thick concrete track and 50 yards on each side hard filled, soiled and seeded over. On each side of this, 100 yards is clear of all buildings, giving a total width of 400 yards free from obstructions. At the termination of the lunch at Filton, Professor Robertson retired from the chair and inducted Mr. I. V. Robinson, who will hold the office of President for the coming year.

FURTHER CENTRAL LINE EXTENSION.

It will be recalled that the extension of the London Transport Central Line eastwards will eventually bring into use a loop serving Gants Hill, Newbury Park, Fairlop, Hainault, and several other stations. Until recently, the lines had been opened only as far as Woodford on the main Central Line to Epping and Ongar, and Newbury Park on the loop, but on Monday, May 31, Barkingside, Fairlop, and Hainault—the three stations beyond Newbury Park—were opened to passenger traffic. This brings into use 1·89 miles of electrified line which was formerly a non-electrified Eastern Region line. Steam-operated goods trains, however, will continue to use the line at night. The London Transport rolling-stock depot at Hainault has now been brought into full use, and, as a result, the frequency of trains during rush hours, on the Central Line between White City and Leytonstone, can be increased by four an hour. Some of the work on the Central Line eastward extension had been carried out before the war, but there has been much to do since the work was resumed. The Hainault depot was used by the British and American armies during the war for assembling rolling stock for North West Europe. It has since been rehabilitated, and is now being used for inspections and minor repairs of rolling stock. It will accommodate 344 cars, of which approximately one fifth would be under cover. The station at Hainault was largely rebuilt before the war. At Barkingside and Fairlop, the old stations have been renovated. The works on the newly-opened section have been carried out jointly by London Transport, who were responsible for laying conductor rails, the provision of electric power, signalling, lighting and telephones; and the Eastern Region, who were responsible for the earthworks and track connections to the main line. London Transport state that they expect to open the northern half of the loop, and the line as far as Loughton, about the end of the year.

THE INLAND WATERWAYS ASSOCIATION.

The second annual meeting of the Inland Waterways Association was held in London on Saturday May 29, the chair being taken by Mr. Peter Scott' M.B.E., vice-president, in the absence of the President, Sir Alan Herbert, M.P. In his introductory remarks, Mr. Scott remarked on the success which had attended the Association's efforts to arouse interest in the economic potentialities of British canals and other inland waterways; when the Association was founded, it seemed to be fighting, if not for a lost cause, at least for one that was nearly lost—but it was in such circumstances, he observed, that the British character showed to the best advantage. He then called upon Mr. Robert Aickman, chairman of the Association, to review the activities of the past year, and the steps taken to promote the principal object, namely, "to advocate the use, maintenance and development of the Inland Waterways of the British Isles for purposes of waterborne trade and as public amenities." The principal item of importance, Mr. Aickman reported, was the encouraging attitude of the Docks and Inland Waterways Executive of the British Transport Commission, as revealed in the course of correspondence and interviews with the representatives of the Association. It had been feared that the Inland Waterways Executive might, in effect, continue the previous policy of the railways towards canals owned by them, and practically force the abandonment of many of them by insisting that each waterway must pay its way independently of the others and by favouring the navigable rivers at the expense of the canals. In fact, the Association

received an assurance that the inland waterways were regarded as having considerable possibilities for the future, both for trade and pleasure; and that four publicity officers had been appointed to encourage and develop traffic upon them. As a means to this end, these officers had been asked to make recommendations for the rationalisation of tolls, some of which, it was thought, had been raised by excessive amounts. The National Physical Laboratory had been investigating the form of the "monkey" or "narrow" boat with a view to its improvement; and a system of interlocking steel sheet piling had been adopted for the repair of canal banks, and would be employed extensively as and when the steel situatiou permitted. In short, the Association were assured, no canal would be abandoned while there was a possible use for it. This, said Mr. Aickman, must be regarded as a very satisfactory outcome; but in other directions there was still cause for concern, particularly in connection with the River Boards Bill, now before Parliament, and the obstacles in the way of using some canals which the owners would prefer to abandon rather than maintain. There were still, he pointed out, a considerable number of waterways which were not nationalised, but sometimes it was difficult to ascertain who was responsible for the maintenance of them; and, in the eastern counties especially, urban water-supply projects seriously threatened the future of these canals.

The Association of Consulting Engineers.

In the course of his speech at the annual luncheon of the Association of Consulting Engineers, held at the Waldorf Hotel, London, on Wednesday, May 26, the Rt. Hon. P. J. Noel-Baker, Secretary of State for Commonwealth Relations, referred to the great part played by the members of the Association in promoting the happiness of the world, and expressed the view that their part would be even greater in the future than it had been in the past. After speaking of the great work of the Tennessee Valley Authority in the United States, he remarked that there were hundreds of rivers in different parts of the world where comparable work could be carried out with great advantage. The part of this country in possible developments, he said, should be no less than that of any other nation, and the part of British consulting engineers should be greater than ever before. Dr. J. F. Crowley, B.A., M.I.E.E., Chairman of the Association, who occupied the chair at the luncheon, thanked Mr. Noel-Baker for his stimulating speech. The toast of "The Guests" was then proposed by Mr. G. Howard Humphreys, M.A., M.I.C.E., and both Sir William Douglas, K.C.B., K.B.E., Permanent Secretary, Ministry of Health, and Mr. J. W. Dulanty, C.B., C.B.E., High Commissioner for Eire in London, responded. The only other toast, that of the Chairman of the Association, was proposed by Mr. J. R. Beard, M.Sc., M.I.C.E., M.I.E.E., and briefly acknowledged by Dr. Crowley. Colonel C. W. G. Walker, C.M.G., D.S.O., is secretary of the Association, whose offices are at 36, Victoria-street, Westminster, S.W.1.

Sheet and Strip Metal Users' Technical Association.—A two-day summer conference organised by the Sheet and Strip Metal Users' Technical Association will be held at the Queen's Hotel, Birmingham, on Thursday, June 10, and Friday, June 11. At 2.15 p.m., on the first day, a visit will be paid to the works of Messrs. Fisher and Ludlow Limited. In the evening at 6 o'clock, at the Queen's Hotel, a technical session will be held, at which two papers will be presented, namely, "Some Fundamental Considerations Relating to the Deep Drawing of Metals," by Dr. A. R. E. Singer, Lecturer in Industrial Metallurgy at the University of Birmingham, and "The Application of Deep Drawing and Pressing to Gas-Turbine Engines," by Mr. H. E. Lardge, of Messrs. Joseph Lucas Limited. On the second day, Friday, June 11, at 10 a.m., a visit will be paid to the works of Messrs. Imperial Chemical Industries, Limited, Metals Division, and after luncheon at these works, members will return to the Queen's Hotel at 3.30 p.m. Following tea at 4.15 p.m., a short discussion on "Strain Age Hardening" will be held. Further particulars regarding the conference or the activities of the Association may be obtained on application to the honorary secretary, Mr. A. McLeod, 49, Wellington-street, Strand, London, W.C.2.

LETTERS TO THE EDITOR.

PROFESSIONAL SALARIES.

To the Editor of Engineering.

Sir,—The letters and editorial articles in Engineering show that Australia is not the only country in which professional salaries are unsatisfactory. I wish to state explicitly what appear to be the essential features and to make some provocative proposals. The present situation is dangerous for both the nation and the profession, in that it discourages the entrance of able men to the profession, and, by a general air of despondency, discourages performance at top form by existing members of the profession. The situation cannot be remedied except by the organised activity of engineers; this is the theme of practically all writers, and is implicit in the issue of a "Charter" by the Association of Scientific Workers. The only question at issue is, what sort of organised activity.

There is a need for incentives. This was the title of your leading article on January 30, 1948, and the need applies to financial incentives for professional engineers no less than to other incentives and other personnel. This means, among other things, that any organising must not be so confining as to leave no room for discussion and agreement between the individual employer and employee. The difficulty in defining classifications, and appropriate salaries, is widely recognised. The situation must not be allowed to degenerate to the state where only the most competent arithmetician can keep the time rate of assessment of his legal income in step with the time rate at which he becomes entitled to it. (I avoid "earns it.")

I make the following suggestions. Firstly, to preserve incentive there must be, for any defined class of work or worker, not a salary, not a minimum salary, not even a maximum salary, but a whole series of salaries. The employee can then progress from bottom to top by the simple process of satisfying his employer. The first duty of the organisations of employers and employees is to negotiate a mutually satisfactory degree of variation, preferably without rigid upper and lower limits.

To maintain a satisfactory inflow of personnel, it is necessary that the general level of this variable salary should be satisfactory. The second duty of the organisations of employers and employees, therefore, is to negotiate a mutually satisfactory general mean salary level from which individual salaries may vary up or down. The third duty of the organisations is to police these two agreements.

Those engineers who have mastered the intricacies of quality control will realise that, when an agreed mean and an agreed variability are maintained, there can be little wrong with the product, whether it be a component or a salary. The adjustments of individual salaries might well be personal matters between individual employers and employees, and not the concern of the organisations; their business starts and finishes with negotiation and the policing of means and variabilities.

It will be clear, of course, that, if the mean salary level is definitely fixed, the salary of one employee cannot be raised without lowering that of others. Freedom can be injected into this quite unpractical system by taking another leaf out of the quality-control book: the organisations negotiate a definite ideal mean, but the mean of the salaries of a finite group of employees may differ from the ideal mean by an amount which depends upon the variability agreed, and upon the number of employees in the group. In this way, reasonable alterations to the salary of one or a few employees do not put the mean outside the control limits.

The variation in salary within one defined employee group can be fairly large, and few groups are necessary. Salaries in different groups will overlap greatly and it is a matter of little moment to which group border-line individuals belong. As a consequence, difficulties of classification are not important. In theory, the method may be applied voluntarily to the employees of one employer, or by Act of Parliament to all employees in the country. It is possible to combine a number of small groups into one larger group having overriding control without losing the individuality of the original groups. There is appreciable benefit in such combination up to a total of about 1,000 employees. There is no practical benefit in building up groups of more than, say, 10,000 employees. In short, the method is flexible and lends itself to decentralisation.

Adequate control of professional salaries is a problem in democratic technique. Its practical solution is closely linked with the growth, or decay, of the democratic nations. You are to be commended, Sir, on the space which you devote to this problem, and it is to be hoped that the efforts of those working on it may soon be crowned with a measure of success.

Yours faithfully,

J. R. Bainbridge.

13, Salisbury-street,
Melbourne, E.10,
Australia.
May 10, 1948.

ENGINEERING UNITS OF FORCE.

To the Editor of Engineering.

Sir,—Many engineers will view with concern Dr. Kestin's support (Engineering, May 21, page 496) of Mr. Helmer's treatment (Engineering, March 19, page 280) of the formula $F = m a$. In an attempt to make use at one and the same time of both force measured in pounds and mass measured in pounds, the conclusion arrived at in both cases is that the formula should be discarded and replaced by the expression, F is proportional to $m a$.

This extraordinary conclusion, viewed in its right perspective, is tantamount to an admission that force and mass cannot be measured in the same units. Dr. Kestin, however, goes farther and suggests the adoption of four "independent" fundamental units, including mass and force in addition to time and distance. One might usefully ponder on the analogy of an attempt to introduce a fourth primary colour, say green, into the world of colour. So, in the world of mechanics, one cannot arbitrarily adopt a fourth fundamental, independent or primary unit for a quantity which is a function of other fundamental units.

Dr. Kestin's reference to the unit of mass adopted for convenience in astronomy was apparently introduced to support the hypothesis that, if there can be a three-unit system (as normally used in engineering and practical science), in addition to a two-unit system (based on l and t only), then there can be no fundamental objection to a four unit system. Such an argument is entirely fallacious. If Dr. Kestin will examine Professor Planck's work* more closely, he will find that the derivation of the two-unit system as used in astronomy is based on acceptance of the fact that F equals $m a$. Only by accepting this formula in its entirety and with all its meaning as regards dimensions, can one arrive at a unit of mass having dimensions $\frac{t^2}{l^3}$. Thus Dr. Kestin conveniently accepts the formula $F = m a$ to build up an argument purporting to prove that the formula should be written, $F = k m a$ or $F = \frac{1}{k} m a$, where k is a constant with dimensions. This savours of mathematical aerobatics.

There is an alarming tendency nowadays to take too many liberties with basic facts and formulæ for the sake of "convenience" of mathematical exercise. Those concerned, in my opinion, are doing a definite disservice to the scientific and engineering world at large and particularly to the student. The latter, being called upon to follow unnecessarily complicated mathematical gyrations, is frequently found nowadays to have failed to assimilate basic principles.

I submit that the origin of much of the confusion in regard to this simple formula and the conception of mass, is due to two factors, viz.: (*a*) the looseness of everyday language, and (*b*) the frequent disregard of the highly trained scientific mind for fine distinctions of speech.

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* *General Mechanics.* Translation by H. L. Brose, page 15. Macmillan 1933.

Thus for many years the phrase "a mass of 1 lb." has been used with only rare attempts to define clearly its meaning. Students of engineering might be told with advantage to compare this phrase with the phrase, "the speed of a train." The latter quantity is not measured in trains but in fundamental units of time and distance. Similarly, "a mass of 1 lb." is not measured in pounds, but is a particular property (measured in fundamental units of weight, time and distance). This definition refers, of course, to what the physicists call the gravitational system. The engineering world, by virtue of its close association with industry and commerce, must adopt this system.

While there is neither time nor space to go fully into the question of invariable standards, I have little doubt that Dr. Kestin joins other eminent scientists and physicists in refuting the Weights and Measures Act of 1855 and regarding the Imperial Standard Pound Avoirdupois as the standard British Unit of Mass. If so, it would be interesting to learn his proposals for a standard of weight as would apparently be required in connection with a four-unit system.

In conclusion, may I quote from two authorities operating in entirely different spheres. First, Frederick A. Halsey, Commissioner of the American Institute of Weights and Measures, states, "It has been proved that established weights and measures cannot be arbitrarily abolished . . ." Secondly, Dr. F. W. Lanchester* has written, "The Question of Convenience . . . It cannot be doubted that, on the whole, any system of units that has grown out of human need or necessity, will have a better prospect of serving such a need than one specially created by scientific men, however eminent."

Yours faithfully,

54A, Creffield-road, R. H. YOUNG.
Colchester.
May 26, 1948.

BARON ROLAND VON EÖTVÖS. (1848-1919).

TO THE EDITOR OF ENGINEERING.

SIR,—The interesting reference to Baron von Eötvös and his torsion balance by Professor A. O. Rankine, in his May Lecture to the Institute of Metals, reported in ENGINEERING on page 522, *ante*, may perhaps justify a brief biographical note on this distinguished Hungarian scientist, the centenary of whose birth at Budapest occurs on July 27.

Baron Roland von Eötvös was born during the abortive attempts to gain independence for Hungary, associated with the famous Louis Kossuth (1802-94). The great grandfather and grandfather of Eötvös had both held high offices under the Austrian Government, but his father, Baron Josef von Eötvös, who had made a name as a writer and thinker, was a supporter of Kossuth and, like him, had to flee the country. Later, however, he returned home, was made a vice-president of the Hungarian Academy, and, in 1867, was Minister of Public Instruction. He was born on September 3, 1813, and died on February 2, 1871. His son, Roland, was educated at Budapest University, but, like so many of his contemporaries, he owed much to his later studies under Kirchhoff, Helmholtz and Bunsen at Heidelberg University, then at the height of its fame. Having obtained the degree of Doctor of Philosophy, he returned to Budapest, where, in 1872, he was given the University Chair of Theoretical Physics, followed by that of Experimental Physics. Science in Hungary was indebted to him in many ways. In 1891, he founded the Hungarian Mathematical and Physical Society; in 1893 he became the President of the Hungarian Academy of Science; and in 1894-5, like his father, was Minister of Education. He died at Budapest on April 8, 1919. *Nature*, in an obituary notice, referring to him as "Hungary's greatest man of science."

Yours faithfully,

EDGAR C. SMITH,
Engr. Capt., R.N. (retd.).

* *The Theory of Dimensions and its Application for Engineers*, by F. W. Lanchester, LL.D., F.R.S. Crosby, Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7.

THE ECONOMIC UTILISATION OF ELECTRICITY.

ALTHOUGH it is unnecessary to point out here that the need for fuel economy is urgent at the present time, the methods by which this economy can best be achieved may well be discussed; and the arguments of those who have expressed opinions on the subject may be examined. In so doing, it is desirable that the broadest possible point of view should be taken. Fuel is consumed in a number of different ways with a variety of ultimate objects. To suggest economies in one particular direction, while ignoring the effect of those economies on the general position may lead to false conclusions. These general reflections result from a study of a paper on "The Economic Utilisation of Electricity in Great Britain," which was read by Mr. R. B. Giles before the Institution of Electrical Engineers on Thursday, April 29. This communication directs attention to the fact that in this country coal has hitherto been treated as an inexhaustible store of heat and energy, which has been available at low cost. A combination of declining production with increasing demand, however, has altered the position. As a result, a resolute conservation of supplies is necessary and the existing intensive competition between coal, gas, oil and electricity must, therefore, be replaced by a policy in which economics rather than finance is the guiding factor.

Having stated, quite correctly, that the efficient generation of heat units and their most economical utilisation for all purposes is the paramount industrial problem of the day, Mr. Giles then fails to deal with this general proposition along the lines its importance deserves. Instead, he discusses the ways in which electricity could, in his opinion, be more economically utilised, as if that were a matter which stood in isolation from other parts of the difficult fuel problem.

Beginning with generation, he points out that the average consumption by auxiliary plant in power stations is now 5·6 per cent. of the total energy generated; and that this proportion could be reduced were it not for the fact that, largely for propaganda purposes, electricity is used instead of steam for operating this equipment. As he gives no figures to support this argument, it is difficult to take it as seriously as he would wish. The same comment may be made, when put forward in that general form, on the statement that electric heating in a power station is "a complete extravagance." It is significant that these are the only items in the economy of a steam power station on which he suggests that savings could be made, although it would not be difficult to mention others, attention to which would have more productive results. He does, however, deprecate the burning of blast-furnace gas when it could be used in gas turbines; and suggests that the methane generated as a by-product in the sewage-disposal systems of Greater London could be utilised for driving a 50 MW generator, assuming a 50 per cent. load factor and a 25 per cent. thermal efficiency. Admitting that no possible source of fuel should be neglected at the present time, this seems to be an illustration in reverse of the advice that steam hammers should not be used to crack nuts. In other words nut crackers are not suitable for dealing with ingots.

Turning from generating stations to the transmission and distribution networks, Mr. Giles's principal criticism is that there is a marked tendency towards the over-provision of equipment. He supports this opinion by the statement that about 50,000 MW of transformer capacity is available to deal with a maximum demand of about 12,000 MW; and that the Central Electricity Board probably had a reserve of not less than 5,000 MW out of a total capacity of 14,000 MW. This capacity was energised solely to ensure that no interruption of supply occurred, a risk, he considers, which should be taken in the present circumstances. Similarly, many miles of cable existed awaiting breakdowns which never occurred.

In the course of the discussion on the paper, Mr. J. Hacking pointed out that when two transformers are working in parallel, although the iron losses are doubled, the much greater copper losses are halved. At loads approaching their full capacity the total losses are therefore reduced. Moreover, it often pays to have cables in circuit in excess of the capacity required. It is indeed a little difficult to understand exactly what Mr. Giles's argument is intended to prove; and still more to appreciate the significance of the statement that the capacity of standby plant in continuous use is at present not less than 750 MW, or one-third the estimated plant shortage. It is hard to believe that there has been any excessive lavishness in the provision of transformers and networks, while that there is a deficiency in generating plant is only too evident. In any event, equipment for many reasons must be installed in advance of demand, and, if at any one time, it is adequate, to deal with the demand, and no more, that state of affairs can only be temporary. Mr. Giles himself gives no indication of how he would solve the problem he has propounded in practice; and we cannot help feeling that it is a matter to which too much attention should not be paid.

In another part of his paper, Mr. Giles appears as a protagonist of private generating plant against public supply. His contention is that in a works where any considerable volume of process steam can be raised at pressures of 100 lb. per square inch and upwards, and over 25 per cent. of the total electrical requirements can be generated, it pays to install private plant; and thus relieve the load on the supply undertaking. Generalisation on such a subject, however, is dangerous, for each case must be considered individually. It may, nevertheless, be pointed out that many, probably the majority of, factories do not require process steam. It is also a little difficult to support the view, which is in conflict with his argument, that it would be more economical to install pass-out turbines in works than to obtain the necessary power from the mains. As is well known, the turbine manufacturing capacity of the country is limited. It is therefore the sounder policy to utilise what is available for the production of large sets, operating at a high power factor for general purposes, than to devote it to the construction of smaller units working in isolation.

He is on more solid ground when he points out that, although the substitution of individual drive for the group driving of machine tools results in a saving of power, it may, unless judiciously applied, lead to an increase in the total horse-power installed, to an increased demand for apparent power, owing to the inherently lower power factor of small motors, and to no improvement in maximum demand, coupled with reduced power factor. Further plant is then necessary to correct the power factor, leading to waste both of materials and manufacturing resources. As regards the lighting of factories he points out that it is most economical to employ general illumination of a good standard, rather than individual machine lamps. In dealing with heating, he contends, correctly, that more attention should be paid to conservation by thermal insulation, and Mr. Hacking supported this view by mentioning that experiments at the Building Research Station had shown that the general adoption of this practice would lead to the saving of no less than 40 million tons of coal per annum.

The most controversial part of the paper, however, is that in which Mr. Giles deals with the domestic and commercial uses of electricity. The increases in the water and space-heating loads fill him with dismay, since, in his view, the case against the use of electricity for these purposes is generally unanswerable on a purely thermal basis. On the other hand, district space-heating schemes, utilising the waste heat from generating stations, receive his support and should, he considers, be generally applied, wherever they can be satisfactorily utilised. In fact, his opinion is that the present extension of electric space heating, though intelligible in view of the Government's policy, is regrettable; since it is only economical where rooms are occupied for a short time or where it is employed as a supplement to central heating. Even low-temperature electrical heating, either by tubes or panels, although its lower capital cost makes it attractive, cannot be justified on a heat-unit basis for general home use, in comparison with slow-combustion stoves. There

is also no case, he says, for electric water heaters in the average 6 to 8 room suburban house, so long as a modern and efficient raw-fuel system is available. A further disadvantage at the present time is that the manufacture of electrical equipment requires more skill and more imported raw material than raw-fuel equipment. Electric cooking apparatus is also less efficient than the heat-storage cooker fired by raw fuel.

In the discussion on this paper, Sir John Kennedy described it as "full of inaccuracies, mistakes, misstatements and omissions." Without being so devastating in our criticism we may point out that it was put forward as an "integrating paper"; and as such, in official terms, is intended to give the "full perspective of the developments leading to the present practice in a particular part of one of the branches of electrical science." In reality it is nothing of the kind since much of its contents are *obiter dicta*, unsupported either by arguments or figures. It is a pity, therefore, that so many of his statements were allowed to go by default in the discussion; and, in particular, that so few of those who are concerned with the supply of electricity on a large scale took part. It is, of course, desirable, even necessary, that every industry should constantly examine its weakness, and continuously seek for means of improvement. Such exercises should, however, be conducted without prejudice, whether it be existing conditions or future remedies that are being considered. It is, in fact, just this lack of judicial detachment which appears to us to be the chief weakness of Mr. Giles's paper. We hope that we are not misrepresenting him when we say that he seems to exhibit a distinct bias towards private generation. There are, of course, cases where private installations are justified; and impressive statistics indicating the correctness of this policy can often be produced. The problem, however, is not wholly economic; and should not be considered solely from that or any other particular point of view. In this connection, in fact, it would appear that the industrial public has often been wiser than some of its advisers; and has realised that there are factors in the organisation of their undertaking which are not the less important because they cannot be made to appear as items in the balance sheet.

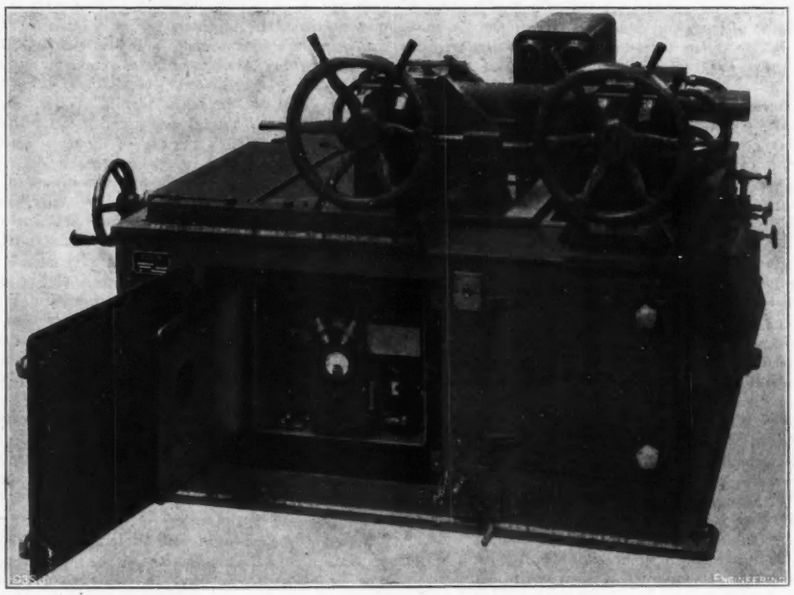
The argument that these hidden items play a part in electricity-supply economy is strengthened when domestic rather than industrial utilisation is considered. If we understand Mr. Giles correctly he would forbid, or at least severely limit, the use of electricity in the home for both space and water heating; and on economic grounds would substitute solid fuel. He does not mention gas. Even in these difficult times, however, economy is not all. It is therefore difficult to see why the housewife should not be allowed to use electricity for these purposes, if by so doing she saves herself labour and acquires a little additional comfort. In so doing, she is not likely to be unduly lavish, owing to the pressure of other expenditure, while the fuel position, for the present at least, will prevent utilisation being as full as might be desired. To suggest that the domestic income should or should not be spent in particular ways opens up dire possibilities which fortunately it is not our province to discuss.

RADIO ADVISORY SERVICE FOR SHIPPING.—The Chamber of Shipping and the Liverpool Steam Ship Owners Association have established a service to give confidential advice to individual shipping firms on electronic problems and to ensure that they are kept effectively in touch with developments. The director of this service is Capt. F. J. Wylie, R.N. (ret'd.) who, until recently, was Director of Radio Equipment at the Admiralty. His headquarters will be at 3, Bury Court, E.C.3.

ALUMINIUM RESEARCH LABORATORY, CANADA.—A large new research laboratory is to be built at Arvida, Quebec, Canada, for Aluminium Laboratories Limited, a subsidiary company of Aluminium Limited. The new laboratory is expected to be completed in 1949. The building and equipment will provide augmented facilities for an already large staff of research scientists and technicians at Arvida. Other laboratories operated by Aluminium Laboratories Limited for industrial research are at Kingston, Ontario, and Banbury, Oxfordshire.

85-KVA ELECTRIC BAR HEATER.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.



85-KVA ELECTRIC BAR HEATER.

THE electrical-resistance heating of steel bars prior to bending, forming and forging, is gradually replacing the older furnace methods, owing to the cleanliness, higher speed and greater uniformity of electrical heating. Scaling is also reduced, owing to the fact that the bar is at a higher temperature for a shorter time, while labour and fuel are economised, as the necessary machine need only be energised and attended when actually in operation; also it has a smaller radiation area than a furnace. The accompanying illustration shows an electrical heating machine which has been designed by Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for heating mild-steel bars from 1¼ to 2⅜ in. in diameter and from 13 in. to 20 in. long to temperatures of about 1,000 deg. C. It was specially constructed for use in conjunction with an existing forging machine and, in order to minimise lifting, the centre line of the jaws was kept down to 31 in. and the overall height to 39 in. The long steel bars handled in the shop in which it is installed can therefore be easily swung over the heater.

The machine illustrated has two heating speeds, the change-over from one to the other being effected on a link board. When using the higher speed, a 2⅜-in. diameter steel bar can be heated to a temperature of 1,000 deg. C. over a length of 22 in. in 104 seconds or a 1¼ diameter bar to the same temperature over a 15 in. length in 20 seconds. It is not, however, always possible to use the higher rate on the smaller bars as overheating results at the point of contact with the clamp, especially if the bars are scaled. Even on the lower tapping, however, the smaller bar can be brought up to temperature in 50 seconds. In a later design five heating speeds can be obtained by the employment of a tapping switch.

The machine is designed for connection to a 400/440-volt single-phase 50-cycle supply and takes about 650 amperes from the line when heating a 2⅜-in. bar at the maximum speed. The size of the connecting cables and of the protective switch fuses are, however, determined by the equivalent direct-current. A conductor cross sectional area of 0·25 sq. in. and high rupturing capacity fuses with ratings of 350 amperes are therefore adequate when bars are being heated at the above-mentioned rates. The 50-cycle heating current is supplied through a transformer which is mounted inside the fabricated steel frame of the heater. It is claimed that the employment of mains-frequency current for this purpose not only obviates the employment of frequency changers, as was necessary with induction heaters, but ensures even heating over the whole cross-section of the bar, owing to the small "skin effect." The outer surface of the bar is therefore maintained at a high temperature for the least possible time, with the result that scaling is reduced. The heating current is conducted to four water-cooled copper blocks by flexible copper rope, thus permitting contact to be made with the bar over a large area and ensuring better current distribution than if one clamp were used at each end of the bar. Bars can be loaded either from the front or ends of the machine and are clamped horizontally, pressure being applied by the hand-operated screw mechanism visible in the illustration. The length of the bar to be heated can be varied by altering the distance between the two sets of clamps by a handwheel, the moving clamp being spring loaded to allow for expansion as the bar heats up. The illustration shows the clamp closed to take the minimum length of bar. Both the transformer and the clamps are water-cooled, a total flow of about 4½ gallons per minute being required for these purposes. For economy a cooling tank and circulating pump can be installed.

When the bar reaches the required temperature, the heating current is cut off by a radiation pyrometer of the Radiovisor control type, the "eye" of which is mounted under a cover on the top of the machine, while the control panel is installed in the base as shown in the illustration. Thereafter the current is switched on and off at intervals so that the bar is maintained within ± 30 deg. C. of the set temperature if it is not required immediately for use. This pyrometer is connected to a photo-cell which is designed so that its resistance changes only with the amount of infra-red radiation falling on it. Inaccuracies due to variations in the shop lighting are thus prevented. The current through the cell is amplified and used to operate the main contactors.

WELDING COMPETITION.—In a competition for the design of a work-piece the Council of the Institute of Welding have awarded the prize to Mr. R. A. Iddon, of Messrs. G. A. Harvey (London), Limited. Mr. Iddon's design, which will be published in the *Transactions* of the Institute, is for a welded box, to be tested to destruction under hydraulic pressure.

UNITED KINGDOM TIN PRICES.—The Ministry of Supply announce that, as a result of increases in the prices of Malayan and Nigerian tin, the United Kingdom selling price of the metal, of 99 per cent. minimum up to 99·75 per cent. tin content, was increased as and from June 1 from 519*l.* to 569*l.* a ton f.o.b., United Kingdom port or delivered at United Kingdom consumers' works. Other grades have been correspondingly varied as follows: refined tin of 99·75 per cent. minimum purity has been increased from 522*l.* 10*s.* to 572*l.* 10*s.*, a ton and metal of 99·9 per cent. minimum purity, in 28 lb. ingots, from 527*l.* to 577*l.* a ton. Grain bar tin has been increased from 539*l.* to 589*l.*, a ton and granulated tin from 544*l.* to 594*l.* a ton. The customary extra charges for small lots, packing, and other services will continue to apply. Inquiries regarding the new prices should be addressed to the Directorate of Non-Ferrous Metals, 20, Albert-street, Rugby. (Telephone: Rugby 2131.)

JOHN HENRY HAMILTON AND HIS WORK.*

By H. J. GIBBONS.

I AM greatly honoured at being asked to give this lecture on the subject of "John Henry Hamilton and his Work," for I am sure that I worked longer with Hamilton than any other man; it was from 1898 to 1930, when he retired, and I was still in almost daily contact with him until his death in 1932. I have vivid memories of the first Akroyd Stuart Lecture, by Professor William Robinson: Hamilton was present and I sat with him. I also had the privilege of attending at a special luncheon meeting in 1940, to celebrate the 50th anniversary of the Akroyd Stuart patent on compression ignition, when a joint paper was given by Mr. T. Hornbuckle and Mr. A. K. Bruce.† In my remarks, I mentioned that the Akroyd Stuart patent for compression ignition, and Hamilton's patent for positive scavenging were taken out within a few weeks of each other.

John Henry Hamilton was born at Estersnow, Co. Roscommon, Ireland, on November 5, 1858. His father, the Rev. Frederick Hamilton, was vicar of the parish. No particulars are available of his early education, except that he went to a private school, and displayed an early and marked talent for mathematics, and mechanical ingenuity. He served his first apprenticeship with Messrs. Douglas and Grant, of Kirkcaldy, from 1874 to 1876, and was afterwards with L. Sterne and Company, of Glasgow, until 1879, where he was associated with Mr. (later Sir) Dugald Clerk on experimental work relating to explosions produced in closed vessels. Clerk was engaged at that time in trying to produce a two-cycle gas engine. Hamilton appears to have left Sterne's in 1879, and another pioneer of the internal-combustion engine succeeded him—Hugh Campbell. Apparently, when Hamilton was in Glasgow, he attended Anderson's College (presumably evening classes), where it was predicted of him that he would have a great future.

After leaving Sterne and Company, Hamilton was engaged in London with two firms, Richard Moreland and Sons, pump makers, in City-road, and Hayward-Tyler and Company, also pump makers, now at Luton. While with one of these firms (I think, Moreland), Hamilton answered an advertisement of a mineral-water manufacturer, who offered a cash prize for the design of a machine which would produce a suitable bottle stopper. Hamilton won the prize, but his success led to his dismissal from his job. Although he had done the work in his spare time, his employers thought that it distracted his attention. This incident apparently did him good, for immediately Messrs. Douglas and Grant took him back to Kirkcaldy, where he took part in the design of large steam engines of the Corliss type, up to 4,000 indicated horse-power, for driving textile mills in India and elsewhere.

Apparently, during this period, there was a close personal relationship between Hamilton and his chief, Mr. Douglas. Douglas and Grant were not a very large concern, but they handled heavy work with relatively small and out-of-date machine shop equipment. Doubtless this developed Hamilton's initiative in devising and putting down special-purpose machines. Evidently Hamilton went back to London afterwards, as I learned from Professor F. W. Burstall, of Birmingham University, that he met Hamilton at evening classes in 1885 at the Birkbeck Institute. Hamilton was then studying for his B.Sc. and was working as a designer for a firm making soda-water machines, possibly the firm from whom he won the prize, previously mentioned.

In 1886, Mr. Arthur Rollason, of Newcastle-on-Tyne, applied for Patent No. 7427 (1886) for a six-stroke engine called the "Beck," and asked Professor Burstall's brother for a good draughtsman. Hamilton was introduced to Rollason and apparently worked with him and, there is no doubt, designed all the details of the Beck gas engine. According to Professor Burstall, one of these engines was tested by Professor Kennedy at that time. Like many other types, the Beck engine was designed to get round the "Otto" patents, which were upheld in this country by Crossley Brothers, Manchester, until 1890, when they expired. The engine was made for the Beck Company by Messrs. Black, Hawthorn and Company, of Gateshead-on-Tyne.

In 1889, a company was formed in the Midlands, called the Midland Engineering Company, Limited, who claimed to be the sole proprietors and manufacturers of the Beck gas engine. I have a copy of the prospectus, which is dated March 8, 1890. The manager was Rollason, and in the prospectus were given particulars of the contracts of service of both Hamilton and Rollason. The date of Hamilton's agreement was July 1, 1889. The prospectus stated that "the Directors were fortunate in securing the services of Mr. Arthur Rollason and Mr. J. H. Hamilton, B.Sc., who has had a large experience in designing gas engines." It gave a list of users who had put in Beck engines, and claimed that they were giving great satisfaction. It also stated that the manufacture of gas engines was in very few hands, and that the demand was increasing for large sizes, especially for engines of 8 to 10 h.p.!

The Midland Engineering Company did not survive, as only 700 shares were taken up, 7,000*l.* as against the 80,000*l.* originally planned; the company was voluntarily wound up on July 10, 1890. Rollason and Hamilton then joined five brothers named Wells, who took over the factory at Sandiacre which the Midland Engineering Company had acquired, and a partnership of seven was formed, being the five brothers Wells, Rollason, and Hamilton. The two principal financial partners were then Alfred Ernest Wells, managing director of Edgar Allen and Company, Limited, Sheffield, and George Henry Wells, of Eckington Collieries. This partnership was established in 1890, to manufacture Premier gas engines, and by the time the Premier Gas Engine Company's prospectus was issued, the firm had a well-established reputation for its engines, and particularly mentioned the positive-scavenging arrangement.

The two so-called "idle" strokes in the Beck engine (a six-cycle as compared with the Otto four-cycle) considerably improved the output in comparable sizes of cylinder, and this undoubtedly induced Hamilton to change over from the Beck engine when the Otto patents expired and thus invent and introduce his scavenging method into the Premier, by making a four-stroke with the air supply from the large end of the piston.

Hamilton applied for the provisional patent of his positive-scavenging engine (which developed into pressure charging) No. 6015 of 1890, on April 21, 1890—the year in which the Otto patents expired. The wording of his patent reads as follows: "In this type of gas or vapour engine, wherein the motor piston makes one effective stroke in two revolutions when working at full power, it is usual to retain some of the products of combustion in the cylinder to mix with the incoming charge. The object of this invention is the construction of an engine in which these products of combustion shall be replaced by pure air and in which this shall be effected in a simple and mechanically efficient manner. For this purpose, I connect or cast with the motor piston a larger piston which is formed also to act as a guide block and which reciprocates in a cylinder cast as part of the bed plate. To the back of this cylinder and concentric and in a line with it I bolt the motor cylinder provided with the usual water jacket. The space between the two pistons acts as an air pump to slightly compress air and force it through the combustion chamber at the end of the motor cylinder during the latter part of the exhaust stroke . . ."

The complete specification was voluminous, occupying five or six pages. In the abstract from the patents, it is noticeable that he had not used any expression of "positive scavenging." The first engine of this type was shown in a small pamphlet issued by Wells Brothers in 1892, with the following description: "In these engines, the Otto cycle has also been adopted but the residual products of combustion, instead of being retained to mix with the explosive charge, are expelled and replaced by a charge of pure air previous to the admission of gas and air. This results, not only in more perfect combustion, but also in less loss of heat to the cylinder walls, and the latter, as well as the piston and valves are kept in a cooler condition. The pump for forcing the air through the combustion chamber is formed by placing a large piston in front of the motor piston, and as the connecting rod is centred in this large part of the piston, the latter serves to take the lateral thrust of the connecting rod and both the small end bearings of the latter and the slipper have the advantage of being perfectly cool when the engine is working at its full load, and the motor piston is relieved of all the side thrusts which exists in other gas engines." Hamilton also arranged an overlap by closing the exhaust valve later, and opening the admission valve earlier. The first single-cylinder Premier gas engine designed by Hamilton and built by Wells Brothers, with the positive-scavenging arrangement operated by the differential piston, was shown at the Electrical Exhibition at the Crystal Palace in 1891, and was afterwards put down to drive the works; I saw it during my first days in the works in 1898, and it was there for some years afterwards. Its admission valve was horizontal and was fitted on the side of the cylinder. In his second type of scavenger engine, Hamilton adopted an arrangement of vertical admission and exhaust valves which subsequently became universal in all parts of the world. He did not patent this latter arrangement, hence its adoption in almost every other country. One of these engines is still in existence at Bilston, and was shown running during the visit of the Institution of Mechanical Engineers to Sandiacre, in 1937.

Wells Brothers issued a single-sheet price list in October, 1895, which gave the following reference:—"Engines constructed with the patent positive scavenging arrangement, whereby the products of combustion are expelled and a cool charge of air pumped through the cylinder after each explosion." This appears to be the first time that the positive scavenging arrangement was ever mentioned in print. Hamilton did not patent his scavenging system on the Continent. He did so in the United States, but allowed it to lapse early. The Germans visited plants where Hamilton's engines were working, studied indicator cards for mean pressures, and forthwith adopted the scavenging pump. Hamilton never obtained any financial benefit from the Germans and other imitators.

Between 1890 and 1898, Premier engines were developed in single-cylinder and tandem types up to 200 h.p. From 1898 onwards, further developments took place, and single-cylinder engines of the scavenger type, with differential piston, were made in sizes up to 250 indicated horse-power, and tandem engines, with differential piston, up to 500 and 650 indicated horse-power. The first detailed description in any catalogue of the positive scavenging method was one by the Premier Gas Engine Company, Limited, of single-cylinder engines, issued in 1904, which I compiled with the assistance of Hamilton. Although the system of scavenging was very complete, the engine was little more complicated than a non-scavenger engine, and possessed many mechanical advantages which were not found in other engines.

Hamilton's method of positive scavenging, in later years, has been linked up with the present-day British method of independent pressure-charging as against the Continental method of exhaust-turbine supercharging. There is no doubt that Hamilton's original method pioneered the present-day methods. In the second Akroyd Stuart Lecture, given by Mr. Alan Chorlton in 1930, he stated that supercharging was brought out by Dugald Clerk in 1902; he also stated that this system included scavenging in use with supercharging, and mentioned that this was a return to the practice of Hamilton. In the first Akroyd Stuart Lecture, however, Professor Robinson made the following statement:—"I may here state that, so far as I know, the first to use scavenging with supercharging, giving good practical results, was Mr. J. H. Hamilton, B.Sc., of the Premier Gas Engine Company, Sandiacre."

In the early days of Wells Brothers, as the cylinder sizes were small and there was a demand for powers up to 200 h.p., which could not then be obtained out of a single cylinder, Hamilton designed a tandem type of engine, the front cylinder having a differential piston which scavenged both cylinders. These were made in two-cylinder sizes from 55 to 200 indicated horse-power. The tandem type had a considerably improved mechanical efficiency as it only had the one differential piston which scavenged back and front cylinders alternately, and consequently the number and weight of reciprocating parts were reduced.

In 1897, Messrs. Brunner, Mond and Company, of Winnington, Northwich, placed orders for two of the then largest gas engines in the world, one with Messrs. Crossley Brothers, Manchester, described as a 400 indicated horse-power *vis-à-vis* type and one with Messrs. Wells Brothers, Sandiacre, described as a 500 indicated horse-power, which developed into a 650 indicated horse-power. The latter was designed by Hamilton and was of the tandem scavenger type, with front differential piston.

The Premier Gas Engine Company, Limited, was formed on May 1, 1898. The chairman was Robert Armitage, of Messrs. Brown Bayley's Steel Works, Sheffield, and the other directors were Robert Mond (afterwards Sir Robert), of Messrs. Brunner, Mond and Company, elder son of Dr. Mond and brother of the first Lord Melchett; William Statham, of Messrs. Andrew Handyside and Company, Derby; A. E. Wells, of Messrs. Edgar Allen and Company, Limited, Sheffield; and Arthur Rollason, of Sandiacre, Nottingham. Rollason was made managing director, and Hamilton chief engineer. Rollason was managing director for one year only and was succeeded by Hamilton as general manager and chief engineer, and afterwards as managing director.

The Winnington engines formed the subject of H. A. Humphrey's famous paper before the Institution of Mechanical Engineers in 1900-1901. Apparently Brunner, Mond and Company had ordered a Crossley engine in the middle '90's, also a *vis-à-vis* type and described as 60 h.p. nominal, an official test of which took place in 1897. Mr. Humphrey's tests of all these engines, as recorded in his paper, revealed that the Premier engine had an indicated thermal efficiency of 37·76 per cent., then a record for gas engines; whereas that of the larger Crossley engine was 29·42 per cent., calculated on the lower calorific value of the gas. The two Crossley engines referred to were designed by James Atkinson, then chief engineer of that company. He was originally with Manlove, Alliott and Company, of

* Akroyd Stuart Lecture delivered at University College, Nottingham, on March 19, 1948. Abridged.

† See ENGINEERING, vol. 149, page 70 (1940).

Nottingham, who, in the early 'nineties, also made gas engines.

The tests made by Mr. Humphrey formed a landmark in the history of the large internal-combustion engine. The results, showing the high thermal efficiency of the Premier engine, as well as its reliability, immediately brought a repeat order from Brunner, Mond and Company, and also orders from several large firms in England and Scotland. The discussion on Mr. Humphrey's paper took three evenings instead of the one originally intended. Two comments in the discussion are of present-day interest: one by Professor Richard Threlfall, who said that the next generation would certainly begin to feel the pinch of scarcity of coal in this country, as compared with favoured locations in America, and perhaps Australia and China; and the second by Hamilton, who said that "the problem of saving coal, which is our national capital, is pressing and vital, because its successful solution means not only our greater prosperity, but a postponement of the inevitable day when lack of coal will paralyse every industry." It is a coincidence that, in the *Proceedings* of the Institution of Mechanical Engineers, at the same time that Humphrey's paper was being discussed, Herbert Akroyd Stuart was elected a member.

From the tests of the Premier tandem engine supplied to Brunner, Mond and Company, which was coupled to a direct-current generator, it was obvious that the weight of the reciprocating parts of this type, fitted with a heavy differential piston as a scavenging air pump, compelled Hamilton to reduce the rotational speeds. He then altered the type by making an engine with a separate scavenging pump and cylinder, first with an inclined piston, and later with a horizontal piston. The new type was immediately successful, and, while the rotational speeds employed would be considered low to-day, they were then criticised as being too high. This new type of Hamilton's design ranged in four sizes, from 400 indicated horse-power to 1,000 indicated horse-power single-tandem, and the double-tandem sizes from 1,000 indicated horse-power to 2,000 indicated horse-power, the larger cylinders being 38 in. in diameter and 48 in. stroke. The speeds were 160, 140, 125, and 90 r.p.m., respectively.

The first of the large size two-cylinder 1,000 indicated horse-power tandem engines was coupled to a blowing cylinder, all three cylinders being in line. The unit was installed in 1902 at the works of Alfred Hickman, Limited, of Bilston, Staffordshire (now Stewarts and Lloyds, Limited), and is still in operation. The air for scavenging the original blowing engines was taken from the blowing cylinders. Later, Hamilton made alterations, as the scavenging arrangements absorbed some of the blast air, and he then fitted separate scavenging systems to increase the air output. The contracts for blowing engines allowed only a stoppage of 10 hours per fortnight for adjustment and cleaning, though they had to work practically day and night, continuously through the year.

Another memory I have is that Sir Alfred Hickman, of Bilston, then wrote a letter saying that he recognised Hamilton as the most distinguished authority on gas engines in Great Britain. As the first engine installed was so successful, Hickman's placed orders for about 20 large engines of Hamilton's design, to run on blast-furnace gas of low calorific value; all of them, with one exception, are working to-day.

The question of scavenging in those early days was the subject of many patents and much controversy. In one of the law actions which was taken out to protect the Otto patents (Otto *v.* Steel, 1885-1886), Otto claimed "that a portion of the gas from the charge penetrated the residuum, and that his patent is a useful patent." Judge Pearson referred to the argument for the defence, saying that a patent of 1838, by Barnet, was to get rid of the residuum, not to retain it; and the Otto patent was upheld, not only in this action, but in several others.

When Rollason took out his patent, No. 7427 (1886), for the Beck engine, he also claimed the advantage that the heat generated by the explosion raised the temperature of the following charge. When Hamilton tested the Beck engine, he apparently found that Rollason's claim was incorrect, and that the action during the fifth and sixth cycles cleared out all the hot products of combustion; this was found to be a still greater advantage, so he continued this system afterwards with his own positive scavenging.

(To be continued.)

THE INSTITUTE OF METALS.—As announced on page 279, *ante*, the Institute of Metals Platinum Medal for 1948 has been awarded to Mr. R. C. Stanley, Chairman and President of the International Nickel Company of Canada, Limited. At a dinner party at the Savoy Hotel, London, on Wednesday, May 26, given by the President and Council of the Institute, Sir Arthur Smout presented the Medal to Mr. Stanley as he had been unable to be at the annual meeting of the Institute on Wednesday, March 17 or on the occasion of the May Lecture on Thursday, May 13.

LABOUR NOTES.

THE writer of the editorial notes in the May issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, says that it "cannot be escaped" that "in a large number of public references to the shortage of steel, the emphasis is placed more upon the inability of the industry to expand production than on the fact that it will not be able to maintain its present record rate unless ample supplies of coke and scrap are forthcoming." "A lot of people to-day who have only a nodding acquaintance with the industry," he goes on, "seem to be wasting a great deal of time running round in circles, chasing up this and that blind alley, seeking ways and means to increase the nominal target figure to 15,000,000 tons a year. If they have any influence at all, we think they could be better employed in bending their energies to removing the real bottleneck—a shortage of scrap and coke that may yet defeat the production effort that everyone engaged in the industry is now making."

"Any suggestion," he continues, "that the present target figure should be raised without the guarantee that adequate supplies will be available to achieve the present target figure would, in our view, be disastrous, and have the opposite effect to that intended. At present, we have difficulty in persuading some of our members of the urgent need for steel, and in encouraging them to maintain the production records, when they find their furnaces standing idle for want of scrap, and no better service could be rendered to the industry, or, indeed, to the country, than for all talk about increasing targets to stop and for energies to be concentrated in the direction of securing the raw material necessary. Given these, the targets will look after themselves."

"There are," according to the writer of the notes, "millions of tons of scrap lying uselessly idle in Germany. There are difficulties, it is true," he says, "in collecting this, and because of matters of high political policy being involved. Nevertheless, it is only in that direction that the solution of our scrap shortage is to be found. While efforts can be and, indeed, are being made to tighten up scrap collection at home, everyone who knows anything about the business is convinced that as far as home supplies are concerned we are just scraping the bottom of the barrel."

"We cannot too strongly urge," he adds, "that the industry's contribution must not be judged from what it has been able to produce in the past three or four months, but by what it will produce by the end of the year, and while we can justify the hope that production will be maintained at the present high level, it is simply foolish to take it for granted."

At the annual conference of the National Union of Bank Employees, in London last week, Bank officers called for the establishment of joint efficiency committees for their industry. The executive was empowered to approach "the appropriate authorities" and press the proposal. Mr. G. N. Cope, who proposed the resolution on the subject, expressed the opinion that the employers had shown appalling shortsightedness in not recognising the value of trade unionism. Close consultation, he said, between the union and the employers on all problems affecting efficiency would be invaluable to the industry.

A report on co-partnership and profit-sharing in industry, prepared by a committee of the Liberal National Council, under the chairmanship of Sir Geoffrey Shakespeare, was published last week. The committee recommends that minimum wages should be established, by negotiation, for all grades of industry, and that, thereafter, increased earnings should be related to individual output, on the understanding that they are not nullified by the incidence of taxation. The references in the report to co-partnership cover employee shareholdings, profit-sharing, and joint discussions by capital, management and labour, through frequent consultations on all matters affecting the status and interest of the employee or the fortunes of his firm.

In his introduction to the May *Trade Report* of the United Patternmakers Association, Mr. Beard, the general secretary, again exhaustively reviews the questions of wages, prices and profits in the light of the country's grave economic position. In the course of his examination of the problems involved, he says that now that we know the Budget proposals and their effect upon the cost-of-living, "it is clear that prices and price margins will require complete overhaul to enable reductions to be made where possible; but in view of our price structure, this is going to be a very involved and complex job. It would, however, appear to be possible for price reductions to be made, for what can be done by the C.W.S. can obviously be done by the multiple firms. It is obvious, however, that compulsory price reduction or, even stabilisation, will be difficult to maintain without a corresponding compulsory freezing of wages, for one is complementary to the other, and wage freezing would be resisted by the trade unions. Even if basic prices are obtained, increases in wages would obviously be reflected in commodity prices. Nevertheless, the attempt should be made to reduce prices, and, if possible, to increase production, for, as I have already indicated, there is a limit to which prices can be reduced without a corresponding increase in production."

"Having regard to the above," Mr. Beard goes on, "there are facts which we, all of us, as individuals must face, and one is, that, if no profit whatever were paid to shareholders and price margins were reduced to the absolute minimum, we should, without considerably increased production, encounter difficulty in maintaining our present living standard. I have been considering some figures which have come my way which illustrate this point. For instance, Vauxhall Motors, Limited, which is an extremely good firm for wages and conditions, had a total income of nearly 20,000,000*l.*; 4,860,000*l.* was expended in wages, salaries, employee benefit schemes, etc. The shareholders received 174,450*l.*, or less than 1 per cent. of the total income received by the firm. Again, out of every pound received by Messrs. S. Smith and Sons (England), materials took 5*s.* 3*d.*, wages, salaries, bonuses, insurance and welfare took 9*s.* 0½*d.*, 8½*d.* was ploughed back into the business for future development. The Government took 1*s.* 4½*d.* in taxation, and out of each pound the shareholders received 3½*d.*, or to put it another way, 1·5 per cent. of the total income of the firm. The declared dividend of each of these firms may appear to have been high, but one can agree that if the total received was put back into the business, or used in price reduction, the amount would not have been sufficient to have had much effect on our economy."

According to official figures, British coal production in the week which ended on May 15 was 3,161,400 tons, compared with 4,182,800 tons in the previous week. Of the total reduction of 1,021,400 tons, a loss of 790,000 tons was attributed to the Whitsun holiday. Allowing for holidays, a weekly average of 4,220,000 tons is necessary to reach the target of 211,000,000 tons for the year. The output in the first 20 weeks was 80,842,100 tons. Absenteeism, both voluntary and involuntary, increased. Output per man-shift at the coal face was 2·89 tons, compared with 2·94 tons. There was a net gain of 200 in the labour force.

At a meeting on Wednesday last week the General Council of the Trades Union Congress re-affirmed its desire for early action to establish development councils within the consumer goods industries, as recommended by the various working parties. There is said to be a hardening of trade union opinion on the urgency of this matter, and it is hoped that the employers' side may voluntarily co-operate in establishing machinery which both the Government and the unions are anxious to see in operation.

BELGIAN COAL PRODUCTION.—Official statistics indicate that the output from Belgian collieries is gradually returning to normal. Whereas the total for February was 73 per cent. of the average pre-war output, that for March, namely 2,294,000 metric tons, was 97 per cent. of the pre-war production.

INDUSTRIAL USES OF ZINC.—The fourth issue of the "Zinc Bulletin" has recently been received from the Zinc Development Association, Lincoln House, Turl Street, Oxford. Special features of the issue, which contains 12 pages and is well illustrated, include a technical article on the value of heavy zinc coatings, information on zinc eaves gutters, some recent examples of zinc-alloy die castings, notes on diverse uses of zinc pigments, and a description of a modern sea-side bungalow which is roofed with zinc. Copies of the bulletin are obtainable on application to the Association.

LECTURES ON PRODUCTION INCENTIVES.—In the course of a visit which he is paying to this country, Mr. J. F. Lincoln, President of the Lincoln Electric Company, Cleveland, Ohio, U.S.A., is to give an address on the subject of "Production Incentives" at a meeting of the Institute of Industrial Administration and the Institution of Production Engineers, on Thursday, July 1, at 6 p.m. A limited number of tickets for the meeting are available for issue to interested engineers. They should apply for them, and for further particulars, to the Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire.

COMBUSTION.*

By DR. R. PENDENNIS WALLIS, M.I.C.E., M.I.Mech.E.

BROADLY, chemical action can be divided into two classes. Firstly, those which require the addition of heat in order that the reaction can be initiated and sustained, known as endothermic reactions, and, secondly, those in which heat is liberated during the chemical combination known as exothermic reactions. In some exothermic reactions, light as well as heat is evolved, and in these cases the process is called combustion. To the chemist, the production of some valuable compound may be the aim of the reaction, to the photographer the burning of magnesium ribbon or powder is the means of producing intense visible and ultra-violet light, with which to illuminate his subject and thus affect the sensitive silver salts in his photographic plate, while to the engineer, the practical use of combustion is nearly always the generation of heat. The principal sources of chemical energy may be gaseous, as in natural gas, methane, coal gas, coke-oven gas and blast-furnace gas, or liquid, such as petrol and fuel oil, or solid, as coal and coke. In all cases, these substances are composed mainly of hydrogen, carbon or of compounds of these elements called hydrocarbons. The potential energy stored in these fuels is liberated by combining them with oxygen and since there is always a plentiful supply of oxygen available in the air, and it has not to be paid for, air is almost invariably used to carry out the oxidation process.

When elements enter into direct chemical combination to form a compound, a definite amount of heat is either evolved or absorbed. This heat of combination is always a fixed amount and from its very definition may be either positive or negative. When a compound is decomposed into its constituent elements, the amount of heat absorbed or evolved is exactly the same as that which was evolved or absorbed in the original formation of the compound. When both combination and decomposition are involved in a complex chemical change, the heat produced or absorbed is the net result of the two reactions. Some elements form two or more compounds with oxygen, while some of the hydrocarbons exist in the form of very complex molecules, but it has been found by experiment that in all cases the amount of heat evolved in oxidation is dependent upon the final products of combustion and in no way upon any intermediate chemical combination or combinations which may have occurred during the process and before reaching the final result. To take two simple examples. When carbon unites with oxygen it can form the monoxide according to the reaction

$$2C + O_2 = 2CO + 4{,}350 \text{ B.Th.U. per pound of carbon burned.}$$

The two molecules of carbon monoxide produced in the above reaction might be further oxidised as in the reaction

$$2CO + O_2 = 2CO_2 + 10{,}240 \text{ B.Th.U. per pound of carbon in the carbon monoxide.}$$

It is thus seen that the net result is the liberation of $4{,}350 + 10{,}240 = 14{,}590$ B.Th.U. per pound of carbon, which is the same as if the reaction had taken place in one stage according to the equation

$$C + O_2 = CO_2 + 14{,}590 \text{ B.Th.U. per pound of carbon.}$$

Again $S + O_2 = SO_2 + 3{,}930$ B.Th.U. per pound of sulphur.

$$2SO_2 + O_2 = 2SO_3 + \frac{1{,}850}{5{,}780} \text{ B.Th.U. per pound of sulphur.}$$

The heat evolved is the same as if the sulphur had burned directly to sulphur trioxide

$$2S + 3O_2 = 2SO_3 + 5{,}780 \text{ B.Th.U. per pound of sulphur.}$$

The heat generated being independent of the intermediate products has been a blessing and a limitation simultaneously. A blessing in that from an analysis of the final products alone it is easy to ascertain if all the combustible elements and compounds have united with all the oxygen with which they are capable of entering into combination. If this is so, it is known that the maximum amount of heat has been released and the combustion is said to be "complete." It has for many years proved a limitation, for the analysis of the products of combustion of the simplest and the most complex hydrocarbons yields water and carbon dioxide. This does not give the slightest clue to the chain of chemical reactions which follow each other so quickly that it is very difficult to obtain an insight into the intermediate steps.

When only the theoretically necessary amount of oxygen for the complete oxidation of the fuel is supplied, and when the whole of it is used in burning the fuel, the combustion is said to be "perfect." In all practical problems where complete combustion is to be attained, it is necessary to provide air in excess of that theoretically required. This invariably results in loss, and combustion efficiency has been defined as the ratio of the theoretical air required divided by the actual air used to give complete combustion. Another efficiency is sometimes used; this is the ratio of the heat actually released to the total calorific value of the fuel. This is really the efficiency of completeness of combustion and does not indicate the degree of perfection of combustion. It is used in cases of very high rates of burning when it is appreciated that all the fuel will not be completely burned. Which of these efficiencies should be used in expressing the results of combustion will depend upon the type of plant under test. If it is a gas turbine, in which the products of combustion will eventually be diluted ten times with air in order to reduce their temperature to that which can be withstood by the turbine blades, there is little point in restricting the oil burners to the theoretical amount of air, and in this case the important point is to see that as much as possible of the heat in the fuel is released and used to increase the kinetic energy of the gases. If the plant is a Lancashire boiler, in which 85 per cent. of the heat released is absorbed in the furnace by radiation, it is of the utmost importance that the furnace temperature shall be as high as possible and the criterion of efficient combustion is a measure of the excess air. In this case, the first method of defining the efficiency is most useful.

Fig.1.

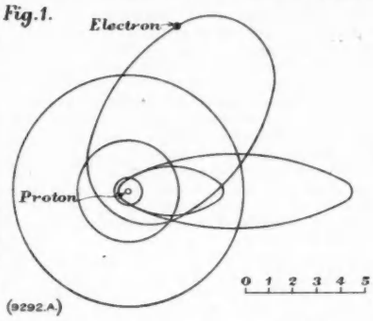


Fig.2.

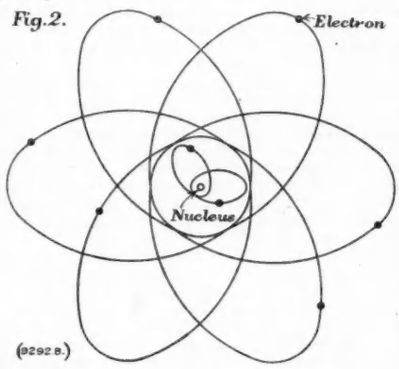
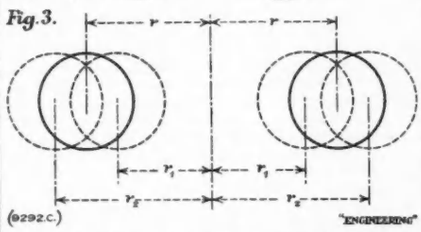


Fig.3.



Most fuels contain hydrogen, and, in addition, many coals, in the state in which they are burned commercially, contain a certain amount of moisture. The products of combustion, if cooled to atmospheric temperature, would contain a weight of water equal to the weight of water in the original fuel, plus nine times the weight of hydrogen. In practice, the products of combustion are not cooled to atmospheric temperature and so the water escapes as vapour without giving up its latent heat. In some countries the loss of this latent heat is regarded as inevitable, and its value is deducted from the gross or higher calorific value and this lower calorific value is used in calculating overall boiler and internal-combustion engine efficiencies.

The speed at which combustion takes place varies enormously. The glow accompanying the slow oxidation of phosphorus in air shows that combustion is taking place, but the rate is so slow that it would take weeks or months to consume a pound of phosphorus. The burning of the first charge in a domestic fire might last anything from ten minutes to an hour, while in a high-speed petrol engine, the combustion of the charge is all over in a hundredth of a second. It is interesting to compare the rates of heat release in different types of combustion equipment and some typical examples are given in Table I.

TABLE I.—*Rates of Heat Release.*

Type of Plant.	Combustion Intensity. B.Th.U. per cub. ft. per hour.	Combustion Intensity. B.Th.U. per cub. ft. per hour per atmosphere.
Gas burners :—		
Natural draught	75,000	75,000
Air pressure 8-in. W.G.	225,000	225,000
Air pressure 2 lb. per sq. in.	700,000	700,000
Concentrated combustion burner	1,500,000	1,500,000
Gas engines :—		
Town gas	5,600,000	420,000
CO	8,800,000	660,000
Petrol vapour :—		
Motor racing car engine	1,000,000,000	48,000,000
Aircraft engine	2,000,000,000	96,000,000
Oil fuel :—		
Marine boilers	290,000	290,000
Velox boiler	890,000	370,000
Gas turbine	23,400,000	5,200,000
Coal :—		
Locomotive boiler	570,000	570,000
Water-tube boilers, with refractory linings and chain grates	25,000	25,000
Water-tube boilers, with water walls and chain grates	40,000 to 100,000	40,000 to 100,000
Water-tube boilers with pulverised fuel	30,000	30,000
Pulverised fuel vortex chamber burning to CO	500,000	500,000

In a cubic foot of gaseous combustible air mixture at atmospheric temperature and pressure, there are 76,000 trillions of molecules. These are moving in all directions and colliding with one another 8,000 million times per second. If the pressure is raised from one atmosphere to two atmospheres, the number of molecules in a cubic foot is doubled and the number of collisions per second will also be doubled. It is, therefore, reasonable to assume that the probability of the meeting of a combustible molecule with the requisite oxygen molecules will increase with the increased number of molecular collisions. In ordinary steam boilers, combustion takes place at atmospheric pressure; in gas turbines at about 60 lb. per square inch or 4 atmospheres; in gas engines, at an average of about 13 atmospheres; while in compression-ignition oil engines it is as high as 27 atmospheres. A better comparison of the rate of heat release in the various types of engineering plant is obtained if the heat liberated is expressed in B.Th.Us. per cubic foot per hour per atmosphere pressure in the combustion chamber and these data have been given in column 3 of Table I.

Even after allowing for the variation in pressure, it will be seen that the heat release obtained in practice varies enormously in the different types of plant. Engineers speak of heat liberated, stored in accumulators or conveyed in a steam cycle, as if it were a material substance that could be manufactured, put into a bottle or carried in a vehicle. While for the purposes of calculation this conception may often be convenient, it does not disclose the true nature of heat or throw any light on such questions as: what decides whether two atoms of hydrogen will unit with one of oxygen if they are brought together; what form does the heat of combination take when liberated; where does the light of the flame come from; why is it sometimes one colour and sometimes another?

Most of these questions are intimately associated with the constitution of atoms and molecules and some knowledge of this subject is necessary if it is proposed to probe into the inner process of combustion. In all cases of engineering combustion, the final products are gaseous. Where the initial fuel is liquid or solid, it often happens that vapour or gas is produced first and this is burned in the gaseous state. In the remainder of cases, combustion is a surface process and the movement of the air to the surface is the predominating factor. The condition of atoms and molecules in gases is, therefore, the all-important consideration.

It has been seen that a gas consists of a very large number of molecules moving in all directions and colliding with each other very frequently. Their velocities will vary from time to time and from molecule to molecule, but, if the gas is in equilibrium, the average velocity in all directions must be the same. When the gas is enclosed in a vessel, the molecules are continuously impinging on its walls and here their direction is reversed. This change of momentum of the molecules is the measure of pressure of the gas and it is

* Paper read before the Liverpool Engineering Society, on Wednesday, March 24, 1948. Abridged.

proportional to the average kinetic energy of the molecules.

When the temperature of a gas is raised, the velocity, and thus the kinetic energy, of the molecules is increased. Temperature is usually measured by the expansion of mercury in a tube, or the variation of the electrical resistance of a wire, but the absolute scale of temperature has been defined by stating that when a given volume of a perfect gas is heated, its absolute temperature is directly proportional to the pressure created. Thus, from this definition, the temperature of a gas depends entirely upon the kinetic energy of translation of its molecules and does not take into consideration any other form of energy which the molecule may possess. This energy is called thermal energy and any increase in thermal energy is accompanied by increase in pressure or work done in increasing the volume of the gas.

The atoms of the heavier elements are complicated in structure, but the study of the lighter ones has thrown considerable light on the mechanism of combustion. The lightest atom, hydrogen, consists of a central nucleus or proton around which there revolves in an elliptic orbit one electron. The proton carries a positive electric charge, while the electron carries a negative charge of equal value. In its planetary motion around the proton, the electron possesses a definite amount of energy which is called electronic energy. While the elliptic orbit of the electron in the normal atom has a definite size and shape, there are circumstances under which it takes larger elliptic orbits and, according to Bohr, the values of the major and minor half axes of the ellipses are restricted to certain values proportional to the squares of the natural numbers 1, 2, 3, etc. The orbits of the hydrogen electron are shown in Fig. 1, on page 549.

These changes increase the electronic energy of the atom by discrete amounts or quanta, but the increases in energy are not equal, being governed by the size and eccentricity of the elliptic orbits. When the electron is in one of the outer orbits, the atom is said to be excited or activated and in this condition it is unstable. After about a ten millionth of a second, the electron returns from the outer orbit to the next inner one and as it does so it emits the difference of electronic energy in the form of a quantum of monochromatic light or a photon. The colour of the light is determined by the frequency of the vibration and this frequency is always directly proportional to the energy released. When the energy emitted is great, the frequency is high and the light is towards the ultra-violet end of the spectrum, whereas in the case of a smaller drop of energy the light is towards the infra-red. This process is repeated and as the electron "falls" from the second outer orbit to the next inner one, another photon of light is given off. The drop in energy in this case will not be the same as in the first, and the colour of the light will, therefore, be different. These successive emissions of different coloured lights are the cause of the characteristic line spectra of the atoms of the various elements.

Excitation can be brought about in three different ways, but in all cases it requires an amount of energy equal to the increase in electronic energy. This energy may be supplied by violent collision with another atom as at high temperature, i.e., thermal excitation. If the atom is hit by a sufficiently swift electron, the electron may give up enough of its kinetic energy to displace the electron in the atom to one or other of the outer orbits, and then itself move on with decreased velocity, and in general, a change of direction. The third method, which is called photo-excitation, is by exposure to light. When an excited atom returns to its stable condition it radiates, and if the emitted photon strikes an unexcited atom of the same gas it may be absorbed by the atom, thereby exciting it to the same state as the atom which emitted the photon.

The atoms of the heavier elements consist of protons, neutrons, mesons and electrons. The most stable of these are the protons and electrons and for the study of combustion attention need be concentrated only on these atomic particles. If an atom has four electrons and four protons, two of the electrons are used to hold together or cement the protons, while the other two electrons move in separate elliptic orbits and the element is helium. Carbon possesses six cementing and six rotating electrons, while oxygen has eight cementing and eight rotating electrons. The oxygen atom is diagrammatically represented in Fig. 2, on page 549.

From consideration of the inert gases, helium, neon, argon, krypton, xenon, and radon, it appears that the free or rotating electrons in an atom arrange themselves in a series of "shells." Thus oxygen has two shells, the first containing two electrons and the second six electrons. As the atomic weight of the element increases, the number of the shells increases, the first shell is complete with two electrons, the second and third shells with eight, the fourth and fifth with 18 and the sixth with 32. The chemical affinity or the valency of an element appears to depend upon the number of electrons required to complete its outer shell. Thus oxygen has six unbalanced or valency electrons in its second or last shell. For perfect balance, there should be eight electrons in this shell. Now each atom of hydrogen has one unbalanced electron in its first shell; so one way of regarding the combination is to consider one atom of oxygen as robbing two atoms of hydrogen of their unbalanced electrons in order to complete its outer shell.

Atoms rarely exist singly: they combine in pairs or more complex combinations to form molecules. Considering a molecule with two atoms, as in Fig. 3, on page 549, the two positively-charged nuclei will repel each other but are tied together by the binding action of the electrons. These bonds, though exceedingly strong, are elastic, with the result that the nuclei are in a continuous state of vibration about their mean position. This nuclear vibration in diatomic molecules is shown in Fig. 3. It is possible for the internal vibrational energy of the molecule to vary, but when it does, it is by definite steps or quanta. This results in certain critical amplitudes of vibration and when the vibration changes from a larger to a smaller amplitude, the molecule emits a definite coloured light.

The energy of chemical combination is probably associated with the valency electrons of the atoms entering into the union and has a definite connection with the form of chemical bond between the atoms. Some little insight into this store of energy may be gained by considering the reverse process, dissociation. For simplicity, consider the dissociation of a diatomic molecule. As the vibrational energy of such a molecule increases, the amplitude of vibration will increase and, for a certain definite value, the amplitude will become infinite; that is the two atoms will swing apart and will not return. This energy of dissociation is stored in the two individual atoms and is again released if they should, at a later time, reunite.

A molecule possesses another form of energy, namely, that of rotation. Here it is the angular momentum which changes in integral steps or quanta. These changes result in relatively small changes in rotational energy and are accompanied by radiations in the far infra-red. If rotational and vibrational changes take place together the magnitude of the latter raises the frequency of the emitted light into the near infra-red region. If an electronic jump occurs simultaneously with these, the spectrum will be emitted in the visible or ultra-violet region. Thus the colour of the light is determined by the type of energy changes within the molecule and its intensity with the frequency with which these occur. Usually at low temperatures, the rotational and vibratory changes are more frequent and the light is red; while at high temperatures more electronic changes take place and the colour of the flame becomes yellow or even white.

According to the older conception, when a gas was in thermal equilibrium, the total energy which it possessed was divided equally between the various forms or degrees of freedom as they are called, and its temperature could be determined by the measurement of any one of the four forms of energy of its molecules, translational, electronic, vibrational or rotational. It was because the energy of translation was assumed equal to the electronic energy that it was possible to determine the temperature of a gas by measurement of its pressure or density or by the radiation which it emits, as in the case of optical pyrometers. Now, since the various forms of internal motion are known to be quantised and the steps or quanta are not all of equal energy, the equipartition of energy can never be exact. Moreover, on the liberation of the heat of combustion the newly-formed molecules are not in thermal equilibrium, and so it is not surprising to find that at first there are notable differences in the values of the various forms of energy.

The means of burning a gaseous or liquid fuel can conveniently be divided into two types: one corresponds to the batch method of chemical manufacture, and the other to the continuous operation method. In the first, the fuel and air are introduced into the combustion chamber, with or without premixing, and then ignited or "fired." The reaction is usually called an explosion and this type of combustion is utilised in the gas and petrol spark-ignition engine and the compression-ignition heavy-oil engine. In this system, the flame starts at one or more points and spreads throughout the whole of the combustible mixture. In the second method, the fuel, with or without premixing with air, is continuously introduced into the combustion chamber as in the case of the Bunsen burner or fuel-oil burner. The flame front is propagated against the moving column of inflammable mixture. Aerated flames have a double cone structure, the inner cone is, in fact, a stationary explosion flame, while the outer cone is a diffusion flame. Flame stability is established by the inner cone adjusting its shape, so that the rate of flame propagation equals the rate of flow of the unburnt mixture through the cone boundary. Most of the fundamental research work on combustion has been carried out by the batch or explosion method, but the essential steps of combustion are the same in each case.

If hydrogen and oxygen molecules are introduced into a vessel at atmospheric temperature and pressure, they will not unite, although there is no doubt that there must be many occasions in which two molecules of hydrogen and one molecule of oxygen meet in a collision. At first, it was thought that it was necessary to raise some portion of the gaseous mixture to a certain critical temperature, generally known as the ignition temperature. Further, that once combustion had been established in a portion of the mixture, the heat from this portion raised the adjacent gas to ignition temperature, and so the flame was spread. It has now been shown that the essential condition for ignition is not an increase in the velocity of translation of the molecules of fuel or oxygen, i.e. their thermal condition or temperature, but activation or excitation of the individual atoms. It is a particular electronic condition which is essential. If two excited atoms of hydrogen are brought into intimate contact with one excited atom of oxygen chemical combination or combustion will take place. As has been seen there are three ways of bringing about the excitation of an atom, and while raising the temperature may be the most common, exposing the gas to an electrical potential or even intense light in some cases would be sufficient to excite the atoms and initiate combustion.

At the instant the union takes place, there is a tremendous readjustment of the energy in the atoms of the newly-formed molecule. New forces come into being, holding the nuclei in their relative positions and determining the shape of the molecule. These forces limit the various kinds of motions of the individual atoms within the molecule, and the general result is a considerable increase in the velocity of the molecule as a whole. The increase in velocity results in increase in kinetic energy and the average kinetic energy of all the molecules is a measure of the temperature of the gas. This is the liberation of the heat and the process by which the temperature of the products of combustion is raised.

Not quite so much is known about the structure of molecules with three and more atoms, but the physicists are working very hard and it is no exaggeration to say that knowledge on this subject increases daily. The atoms of the molecule of water vapour or steam, H_2O, lie at the three corners of an isosceles triangle and this is also the shape of sulphur dioxide, SO_2. The atoms of carbon dioxide, CO_2, lie in a straight line; the molecule of methane, CH_4 is tetrahedral, that of benzene, C_6H_6, a flat ring while those of the paraffins, C_nH_{2n+2}, are like flexible chains or "sausages."

Once ignition had been established, it was regarded that flame propagation was controlled by the transfer of heat from the inflamed to the uncombined gases and depended entirely upon a supply of heat adequate to raise the medium ahead of the flame to the ignition temperature. Experiments by the late Professor W. T. David on the burning of CO and H_2 now indicate that in the early stages after ignition, the flame propagation results from the diffusion of activated particles from the flame front into the uncombined gases and that in the later stages the propagation is thermally assisted in a manner similar to the original conception. The flame front during the early stage of travel is of low luminosity, but in the second stage it builds up to a high luminosity, indicating a high instantaneous pressure and temperature. Turbulent motion of the inflammable mixture before ignition has no influence upon the rate of travel of the flame front in the first stage, but has a marked effect in the later stage.

In the case of combustion initiated by an electric spark, the number of activated atoms will, at first, be relatively small and so any influence which increases or decreases this number will have an apparently disproportionate influence on the rate of the first stage of flame propagation. It is necessary for the energy-rich molecule to retain its electronic energy until it is used in the particular type of collision resulting in combustion. It has been suggested that the action of alkyl halides, which act as combustion inhibitors, may be due to their deactivating the energy-rich hydrocarbon compounds. In the ordinary course of events, the activation energy could be lost by radiation or by collision with other types of molecules, for example, diluents such as nitrogen. Any influence which reduces such radiation or collisions would increase the rate of flame propagation.

In the case of carbon monoxide burning in oxygen, it was found that when the gas was very dry there was a considerable increase in radiation, and the flame speed was much lower than if the gas were slightly damp or if a few per cent. of hydrogen were added to the carbon monoxide. It appears that the collisions between the newly-formed activated CO_2 molecules and the H_2O molecules result in the rapid conversion of the vibrational energy of the CO_2 molecules into thermal energy and the radiation from the flame is correspondingly reduced. Large radiation from the flame front results in there being less energy available

to carry on the activation process, with a consequent reduction in the velocity of flame propagation.

The presence of traces of some other substances act as positive catalysts decreasing flame radiation and increasing flame speed. These include ethyl nitrate, $C_2H_5NO_3$, ethyl iodide, C_2H_5I, and chloroform, $CHCl_3$. On the other hand, carbon tetrachloride, CCl_4, acts as a negative catalyst, increasing the infra-red radiation and reducing the flame speed. Table II is given by Dr. A. G. Gaydon, on the effect of catalysts on the combustion of dry carbon-monoxide in oxygen.

TABLE II.

Catalyst.	Per cent. Catalyst.	Radiation, Cal. × 10⁶	Flame Speed, cm. per sec.
—	0·00	6·00	100
H_2O	0·23	2·76	780
H_2O	0·44	2·39	900
H_2O	1·95	1·63	> 1,000
$C_2H_5NO_3$ ..	0·28	2·30	930
$C_2H_5NO_3$ ..	0·46	2·20	> 930
$C_2H_5NO_3$ ..	0·89	1·56	2,500 ?
C_2H_5I ..	0·18	2·16	> 800
C_2H_5I ..	0·32	1·67	1,100
$CHCl_3$ ..	0·47	2·30	560
CCl_4	0·35	6·34	79
CCl_4	0·72	6·60	44
CCl_4	1·42	6·47	55

When chemical combination takes place, there is a complete redistribution of the total available energy and the final stable condition of equilibrium is not attained instantly. In some experiments, it has been shown that as much as 13 per cent. of the calorific value of the fuel is left in the molecules of the products of combustion in forms other than kinetic energy of translation. This latent energy, as it has been called, is greatest in the products of combustion from the first stage of inflammation. It is less in hydrogen flame gases than in carbon-monoxide flame gases and decreases in value with increase in pressure of the inflammable mixture during combustion. This latent energy is accompanied by an abnormally high proportion of dissociated gases. This energy is unloaded upon a surface when the flame gases impinge upon it and the abnormally dissociated gases recombine and, if the surface is suitable, it radiates a bright luminescence. This phenomenon is called candoluminescence and a very promising application is in the increase of efficiency of gas-fire radiants. Many explanations of this latent energy have been suggested, and there is some evidence that the flames actually contain atoms of hydrogen and of oxygen. Another suggestion is that the newly-born CO_2 molecule is triangular in form and that the transition from this to the normal linear form takes place rapidly with the result that the molecules are left in a long-lived vibrationally activated state and this excess vibrational motion accounts for the latent energy.

Whatever the explanation of the latent energy, there is little doubt that under most conditions the atoms of the newly formed molecules are in a state of electronic excitement. As these give up their extra quanta of energy and revert to "ground level" or normal condition, they emit light and infra-red radiation; this is called chemiluminescence. To what extent the total radiation of the flame is due to chemiluminescence is still a debatable matter, but it appears to be considerably greater than was at one time realised. From an engineering point of view, it will be a great step forward when it becomes possible to control the proportion of energy liberated in this form. In the case of internal-combustion engines and gas turbines, the aim is to convert the chemical energy of the fuel into pressure on the piston or increase in the volume of the gases. This is a purely thermal effect. What is desired is an increase in the kinetic energy of translation of the molecules. Any chemiluminescence only increases the loss in the water jacket of the gas or oil engine or increases the difficulty of maintaining the fire tubes of the gas turbine. In a metallurgical furnace or steam boiler, the requirements are different. The heat of combustion is not required in the products of combustion, but in the "charge" or the water and steam. Once it is liberated by combustion it has to be absorbed by the "charge" or transferred through the furnace of the Lancashire boiler or the water walls and tubes of the water-tube boiler. Here radiation is of the greatest assistance and the greater the energy released as chemiluminescence the greater the heat which will be absorbed by the furnace or water walls and the less the heat which will be left in the gases to be abstracted by conversion in the later banks of boiler tubes.

It has been found that preheating the combustible mixture reduces the amount of energy radiated by the flame. The preheating must, of course, raise the temperature of the flame, and the lowering of the amount of radiation gives further proof that the emission of the radiation is not purely due to the thermal condition of the gases. The greater part of the energy radiated by coal-gas flames lies in the infra-red and varies very considerably with burner design and the degree of aeration of the flame. With very high aeration the amount of energy radiated is about 10 per cent. of the total energy set free by the combustion. This rises to about 18 per cent. for normal full aeration, then falls slightly, to rise rapidly when aeration is decreased and the flame becomes luminous. Under this condition there is a definite shortage of primary air and the reaction results in the formation of particles of finely divided carbon. Before their combustion takes place, these are raised to a white heat and account for the very high degree of luminosity. The same effect is obtained in oil burners, where the more complex hydrocarbons "crack" or become dissociated, forming the lighter hydrocarbons and very fine particles of carbon.

Experiments on explosions in closed vessels have shown that with most fuels the combustion is not complete at the moment that the maximum pressure is reached and particularly with carbon monoxide there is a continuation of combustion or after-burning. This is accompanied with high luminosity and has been known in the case of dry CO in large vessels to persist for 14 seconds, but this is unusually long.

In the combustion of ordinary fuels containing hydrogen as well as carbon, there is little doubt that the carbon is oxidised to carbon monoxide and that the combustion of this gas takes place largely by the reaction $CO + H_2O \rightleftharpoons CO_2 + H_2$. The whole question of the chemical chain reactions in the combustion of the hydrocarbons, however, has been the subject of considerable controversy among chemists. Spectrographs of the flames of burning hydrocarbons show the presence of isolated radicals such as OH, C_2, CH and CN, while chemical analysis indicates the presence of well-known organic compounds, e.g., formaldehyde, H_2CO. The late Professor Bone put forward the view that the initial stages of combustion of the hydrocarbons were the successive introduction of the hydroxyl radical, OH, into the hydrocarbon molecule. The later view advanced by Professor Callender and developed by Professor Sir Alfred Egerton is that combustion starts when a sufficiently energetic hydrocarbon molecule combines momentarily with an energetic oxygen molecule forming a temporary peroxide in a high energy state. The peroxide is unstable, and directly, or by a chain of reactions, breaks down to aldehyde and water. Variations of these theories have been suggested by many chemists, and while final conclusions have by no means been reached, it undoubtedly has been proved that between the initial hydrocarbon and oxygen and the final carbon dioxide and water there is a series of chemical chain reactions in which the above radicals and organic compounds form intermediate products. This view is supported by the fact that if traces of many of the assumed intermediate oxidation products are added to the original fuel they are found to promote the reaction most powerfully.

Both from the point of view of the energy chains in the activation of the molecules and in the probable chemical chain reactions, it is seen that there are several stages in the combustion process where the rate at which the action will proceed is dependent upon a small number of activated atoms or intermediate chemical compounds. Any influence which tends to increase or decrease the number of these vital units will have an extremely marked effect upon the speed of combustion and will, in some measure, at least account for the enormous variation in heat release in different engineering plant as recorded in Table I, on page 549.

Combustion is one of the meeting points of the three great sciences of physics, chemistry and engineering and each has contributed an important share in its elucidation. The combustion engineer of to-morrow will have not only to see that combustion is "complete" and "perfect," but will be expected to exercise some control over the form in which the chemical energy of the fuel is at first released. In some applications it is required purely as thermal energy, while, in others, a high percentage of chemiluminescence is desirable. The time is probably not far distant when these forms of energy release will be controlled at will.

MINISTRY OF SUPPLY REGIONAL OFFICE IN NORTH WALES.—The fact that the Ministry of Supply have now established a North-Wales Regional Office in Caernarvon is indicative of the rapid growth of industry in that region. Most of the factories there have come into existence since the war; there are between 50 and 60 of them, and they cover general engineering, steel and allied trades, wireless and optical manufacture. Some of the organisations have taken over factories built by the Government during the war. The new office will handle all matters for which the Ministry is responsible, including the allocation of materials, the sponsoring of applications for building licences, and the provision of assistance in production problems. Mr. Elias Williams, Assistant Regional Officer at Cardiff, has taken over the new office at "Bryn Liwyd," St. David's-road, Caernarvon. (Telephone: Caernarvon 268.)

AIRFIELD APPROACH LIGHTING.

THE new development in airfield approach lighting for use in foggy weather or at night, which was described by Mr. E. S. Calvert, B.Sc., A.R.C.Sc.I., before the Royal Aeronautical Society on Thursday, April 15, was demonstrated at the Royal Aircraft Establishment, Farnborough on Thursday, April 22. The outline of the runway lights as seen by the pilot of an approaching aircraft may be misleading in poor visibility, and photographs and diagrams exhibited during the demonstration showed the difficulty of touching down accurately on the runway unless there were some form of horizon to aim at. For example, it is not always easy to tell from the configuration of the lighting whether the aircraft is approaching parallel to but slightly displaced from the runway, or whether it is banking over the correct approach line. The new system has been developed in order to reduce such difficulties; in principle it is very simple, and is comparatively cheap to install Moreover, it involves no additional instrumentation within the aircraft, so that the pilot, having been guided to the approach run, is able to concentrate on the view ahead.

The system consists of parallel rows of lights placed horizontally across the approach area at equal distances apart, together with a central line of lights which leads directly to the runway. Each row serves as an artificial horizon, which, with the central line, enables the pilot to gauge the direction and attitude of the aircraft in relation to the ground. The apparent length or angular width of a given row as seen by the pilot when passing over it naturally depends upon the height of the aircraft, becoming larger as height is reduced. Successive rows towards the runway are therefore made progressively shorter in length, and are spaced so that each appears of equal length provided the aircraft is coming in along the runway line at the proper height and at the correct gliding angle. If, for example, the gliding angle were too steep then successive rows would appear to increase in length, and the pilot would alter his flying controls accordingly. The arrangement of the lamps in each row can be used to indicate the distance from the runway. Some of the lighting effects as seen by the pilot were demonstrated by means of the "Cyclorama." This device, which was developed at the R.A.E., reproduces on a screen, which can be viewed directly or through a simple optical system, the pattern of lights as seen from the cockpit of an aircraft which is approaching to land. The intensity of the lighting pattern can be varied to simulate various conditions of visibility and dummy controls produce the visual effects which their action would cause in practice.

In the experimental lay-out at Farnborough, the rows of lamps are spaced 600 ft. apart over an approach run of 3,600 ft., and each row subtends an angle of 2½ deg. with the touchdown point on the runway. Sodium lamps in plain parabolic reflectors tilting 5 deg. upwards, and facing the general direction from which an approach should be made, are used in the rows, while the central line consists of filament lamps set singly or in groups of two at intervals of 100 ft. Dimming arrangements to suit various degrees of visibility are not yet provided, and consequently there is some glare from the system at night. This new development, however, seems to be an improvement over the forms of approach lighting used hitherto, and plans are being made to install the system at London Airport in time for next winter.

RURAL WATER SUPPLIES.—In reply to a question by Mr. R. H. Turton in the House of Commons, on Thursday, May 27, the Minister of Health (Mr. A. Bevan) said that 35 rural water supply schemes covering 609 parishes had been completed since July, 1945. In addition, 1,061 schemes relating to 2,146 parishes had been approved and 656 schemes for 3,052 parishes were under consideration.

GENERATION OF POWER FROM WASTE GASES.—An extension of the power house at the Renishaw Ironworks, Sheffield, has been completed. The new plant, comprising a 1,000-kW turbo-alternator set, will enable electricity generated from waste furnace gases to be supplied to the grid and effect an annual saving of some 5,000 tons of coal. The extension was officially opened on May 26, by Lord Citrine, chairman of the British Electricity Authority.

DISPOSAL OF ROLLING-MILL PLANT AT OLDBURY.—The Freeth-street Works of the Darlington and Simpson Rolling Mills, Limited, at Oldbury, Birmingham, which were engaged until recently in rolling light sections, have been purchased by Messrs. Cox and Danks, Limited, Scapa House, Park Royal-road, London, N.W.10. The property, which covers 5¼ acres, and has canal and railway-siding facilities, will be developed by Messrs. Cox and Danks for the stockholding and constructional engineering side of their activities. The firm will reconstruct the works and this will involve the demolition of an old landmark, the 175-ft. chimney stack.

NOTES ON NEW BOOKS.

Proud Heritage: A History of Thomas Smith and Sons (Rodley), Limited. By FREDERICK H. SMITH. Thomas Smith and Sons (Rodley), Limited, Town-street, Rodley, Leeds.

THE well-known crane-building firm of Thomas Smith and Sons began in 1820, in the then separate hamlet of Rodley (now a part of Leeds), as a partnership of "Millrights and House Furnishers," the partners being Jeremiah Balmforth, David Smith and Jeremiah Booth; Mr. F. H. Smith, the author of this history of the firm and a joint managing director, is David Smith's grandson. Unfortunately, few records survive of the activities of the partnership, but it appears that the construction of cranes began in 1840, and that both of the Jeremiahs were out of the business by 1858. David Smith died in 1859 and the direction then passed into the hands of his son Thomas, who was only 21 years of age. Two years later, he bought out Jeremiah Balmforth's son, William, and the undertaking continued as a completely-owned family concern until 1939, when a controlling interest was acquired from the three sons of Thomas Smith by Thos. W. Ward, Limited, of Sheffield. It will be seen, therefore, that the author of this attractively produced book is unusually well equipped to write the history and to make good from family recollections the gaps in the early written records.

Reviews of Petroleum Technology. Volume 7. *Covering* 1941 *to* 1945. DR. F. H. GARNER, honorary editor. The Institute of Petroleum, Manson House, 26, Portland-place, London, W.1. [Price 21*s.*, post free.]

BEFORE the war and up to 1940, these *Reviews* were published annually; they gave a most comprehensive summary of the year's published literature, principally British and American, on petroleum technology. The latest volume covers the remaining war years, but the chapters on certain subjects have had to be deferred to the next volume, which is now being prepared. As in previous years, each chapter has been written by a specialist, and very full lists of references are given; altogether, there are references to nearly 3,500 articles. In the chapter on petroleum geology, it is suggested that the time has come for the presentation of a well co-ordinated account of the current knowledge on the origin of petroleum. It would provide a useful basis for further work, and, as the subject is now so complex, a wide range of scientists, rather than geologists alone, should be employed on future research. In a chapter on drilling, it is noted that a record for depth was established in Texas, where a well was drilled to a depth of nearly 17,000 ft. in 1945. Reservoir engineering, reservoir control, and well engineering are dealt with in a chapter on "production engineering." Much of the information contained in an interesting chapter on "petroleum transportation in the U.S.A." appears to be published for the first time. Owing to the war, the value of alternative fuels was enhanced; particular mention is made of hydrogenation, the Fischer-Tropsch process and low- and medium-temperature carbonisation. Two chapters are devoted to specifications for service fuels and war-time specifications for lubricants. No outstanding developments took place in the methods of manufacturing asphaltic bitumen in the United Kingdom, but the wet-sand process, and soil stabilisation were applied to the construction of roads and aerodromes. There are also chapters on geophysics; refinery-process developments; analysis and testing; chemistry of petroleum; physics of petroleum; natural gas, liquefied petroleum gases, and natural gasoline; benzole; Diesel fuel and gas oils; petroleum literature (*i.e.*, books and pamphlets); and one dealing with derived chemical products, special hydrocarbon products, synthetic resins, synthetic rubber, etc.

Vibration in Machinery. An Introduction to General Principles. By DR. W. A. TUPLIN. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 8*s.* 6*d.* net.]

DR. TUPLIN has written so much on engineering subjects that the second edition of this book, six years after the appearance of the first, needs only brief mention. The publishers are to be congratulated on the welcome accorded to the book, which at a price that is modest by present standards, should prove useful to a wide circle. This edition, however, is substantially the same as the first, which is a matter of regret, since several important papers that might have found a place in the bibliography have been published during the past six years. Further, in a book of this kind the treatment of several topics is necessarily brief and the reader may well feel the need for guidance in passing from the consideration of general principles to the working out of specific problems; the inclusion of graduated exercises with answers would have remedied this. Few subjects remain static over a period of years, and this aspect should be reflected in successive editions of a book.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

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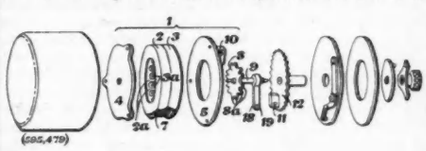
ELECTRICAL APPARATUS.

595,479. Electric Impulse Producer. R. C. Graseby, of Itchenor, Sussex. (3 *Figs.*) July 4, 1945.—This invention is an electric apparatus for producing oscillatory movements or electrical impulses of controllable frequency. The synchronous electric motor 1 is of the known kind and comprises a stator composed of two coaxial soft-iron rings 2 and 3 of channel section clamped together between frame plates 4 and 5. The inner walls of the rings are formed with teeth 2*a* and 3*a* extending parallel with the axis of the rings and inter-leaved as shown. The winding of the motor consists of a coil 7 placed between the rings 2 and 3, and the rotor is a permanent disc magnet 8 mounted on a spindle 9 carried in bearings. The rotor has a number of pairs of poles 8*a* each having an overall width of two adjacent teeth 2*a* or 3*a* and these poles are located close to the teeth and in the meeting plane of the two rotor rings 2, 3. When an alternating current is supplied to the stator coil 7, the polarity of the stator teeth 2*a*, 3*a* is continually reversed and the rotor is thus caused to rotate in one or other direction. A fixed contact 10 is mounted on the frame plate 5 and an adjustable contact 11 is



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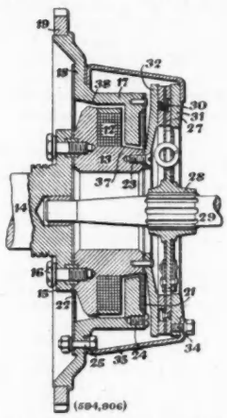
mounted on a rotatable toothed locating disc 12. On the rotor spindle 9 is secured an arm 18 carrying a contact 19 placed so that it may be brought into engagement with either the fixed contact 10 or the adjustable contact 11 as the rotor turns in one or other direction. When the stator coil 7 is supplied with an alternating current, the polarity of the stator pole pieces is continually reversed. The rotor 8, 8*a* is thus caused to move in one direction or the other, the movement continuing until the contact 19 engages one of the contacts 10 and 11 whereby an impulse of current is sent to the appropriate circuit. The rotor 8, 8*a* is arrested and immediately the polarity of the stator pole pieces reverses so that the rotor 8, 8*a* moves in the opposite direction until the contact 19 engages the other of the contacts 10 and 11. Thus the rotor continuously oscillates about its axis of rotation, the amplitude of the oscillations and, therefore, the time interval between successive engagements of the contact 19 with the contact 10 or 11, being determined by the position of the adjustable contact 11. (*Accepted December 5, 1947.*)

MOTOR VEHICLES.

594,906. Electromagnetic Friction Clutch. Humber, Limited, of Stoke, Coventry, and A. C. Sampietro, of Coventry. (3 *Figs.*) June 19, 1945.—The object of this friction clutch is to reduce frictional wear to a minimum. In the construction shown, the electromagnet consists of an annular energising coil 12 supported by an L-shaped ring 13 of magnetic material, which is secured to a flange 15 of a driving shaft 14 by screws 16. The armature 17, also an L-shaped ring of magnetic material, is attached to an annular extension 18, which carries externally a toothed ring 19 arranged for engagement with a starter pinion in the usual manner. The armature 17 and extension 18 are supported by means of resilient spiders 21, 22 secured to the electromagnet by means of screws 23 and screws 16, respectively, and connected to the armature and its extension by means of screws 24 and bolts 25, the spiders being torsionally rigid but allowing of axial movement. In this way, the armature is supported for axial movement with respect to the electromagnet and is held in driving connection with the driving shaft 14. The clutch is of the single-plate type, consisting of a driven clutch disc 27 fast with a hub 28, which is splined so that it can slide upon a driven shaft 29. The disc 27, when the clutch is engaged, is clamped between a driving face 30 and the face of a presser-plate 31, which can be moved axially with respect to the disc 27 and is in driving connection with it. The driving face 30 is on a disc 32 secured to the magnetic member 13 of the magnet by the screws 23, and the presser-plate 31 is attached by screws 34 to a casing 35 enclosing the clutch and connected to the extension 18 by the bolts 25. This



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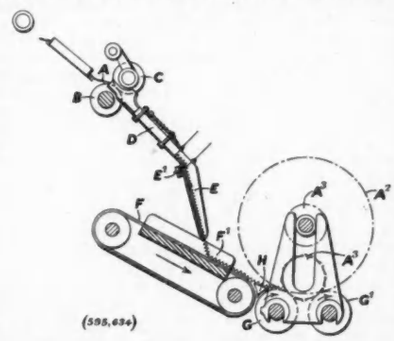
casing thus provides a mechanical connection between the extension 18 and the presser-plate. The magnetic circuit includes a frustro-conical air gap 37 between corresponding frustro-conical surfaces on the electromagnet and its armature, and, in series with it, a second similar frustro-conical air gap 38. In operation energisation of the electromagnet will effect axial movement of the armature 17 to the left, to clamp the driven clutch disc 27 between the driving face 30 and the presser-plate 31. (*Sealed.*)

TEXTILE MACHINERY.

595,634. Sliver-Crimping and Roll-Forming Machine. Fairbairn Lawson Combe Barbour, Limited, of Leeds, and J. R. Bee, of Leeds. (3 *Figs.*) October 23, 1944. This invention is a sliver-crimping and roll-forming machine for making a roll which is intended for use on a spinning frame. The sliver A, after being passed between the delivery rollers B and C of a doubling machine for winding bast and similar fibre slivers into roll form, is packed into a crimped form by being passed through a slidable spring pressure box D. After leaving the crimping box D the crimped sliver passes down a trough E to which an oscillatory motion is imparted about the centre E^1. Situated below and close to the delivery end of the trough is an inclined travelling feed sheet F on to which the sliver is deposited in a zig-zag or folded condition due to the oscillatory motion of the trough. The travelling feed sheet is continued as closely as possible to one of the roll-winding rollers G, G^1, the space between



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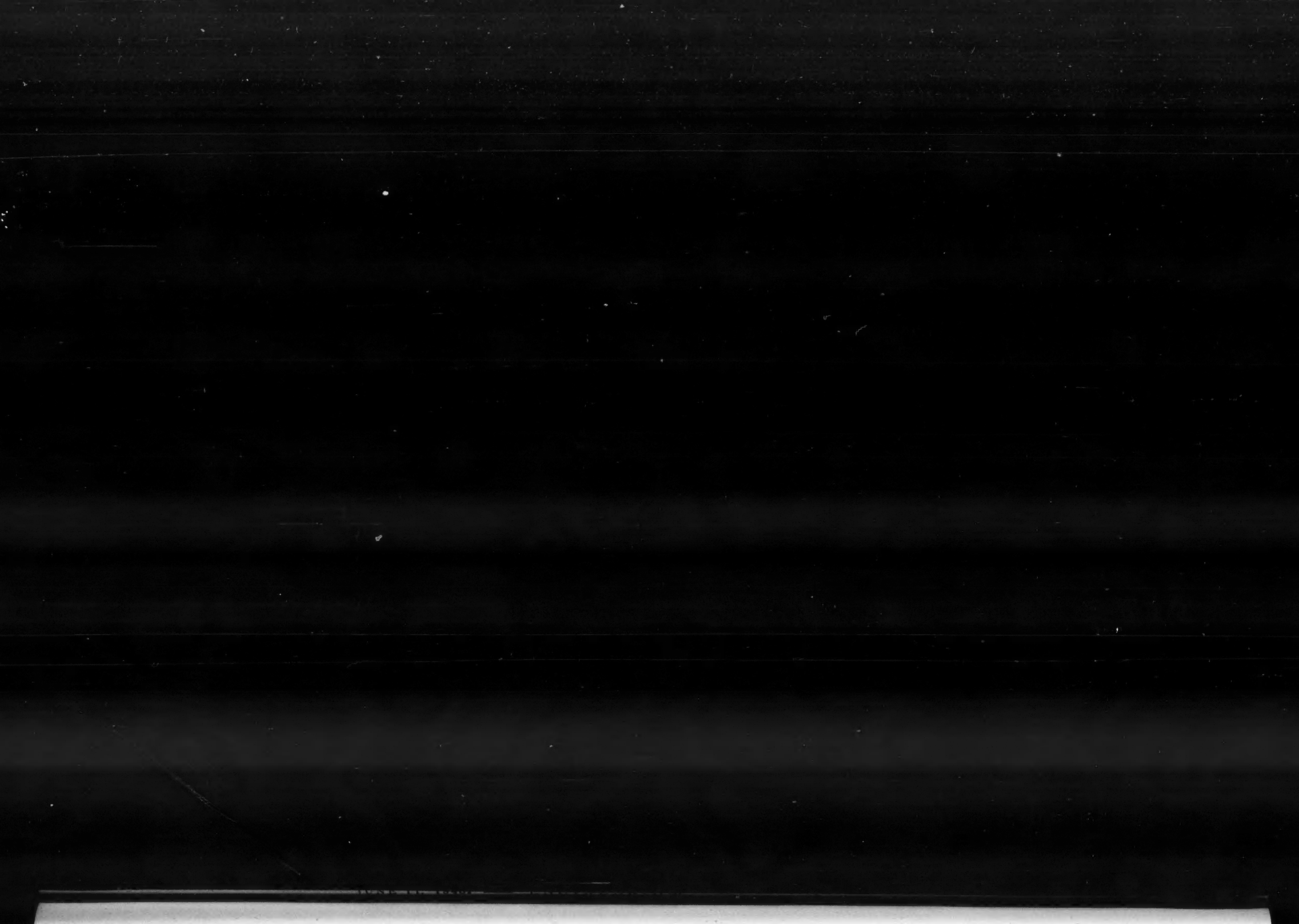
the feed sheet and the roller G being filled in by a support H. Guides F^1 are provided at the edges of the travelling feed sheet to keep the crimped and folded sliver within the width of the sliver roll A^2 into which it is wound after leaving the travelling feed sheet. This is done by winding the sliver on to a core A^2 that is pressed on to the two winding rollers G, G^1 which are rotated in the direction indicated by the arrows. A roll constructed in this way causes little or no circumferential binding of the fibres and in order to form a compact roll which can be handled safely without disintegration and which will unwind without disturbing the formation of the roll, as required for use on a spinning frame, the zig-zags or folds can be made more or less condensed by varying the relative speeds of motion of the trough E and the travelling feed sheet F on to which the sliver is deposited before being taken to the roll-forming machine, until the best winding conditions are obtained for producing satisfactory cohesion. (*Sealed.*)